# TECHNOLOGY ASSESSMENT & FORECAST

*The Patent System added the fuel of interest to the fire of genius.*

A Lincoln

U.S. DEPARTMENT OF COMMERCE / Patent and Trademark Office

# TECHNOLOGY ASSESSMENT & FORECAST

## EIGHTH REPORT
## DECEMBER 1977

U.S. DEPARTMENT OF COMMERCE
Juanita M. Kreps, Secretary

Jordan J. Baruch
Assistant Secretary for Science and Technology

Lutrelle F. Parker
Acting Commissioner of Patents
and Trademarks

William S. Lawson
Director, Office of Technology
Assessment and Forecast

U.S. DEPARTMENT OF COMMERCE
Patent and Trademark Office

U. S. Depository Copy

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

Stock No. 003-004-00550-5

CONTENTS

INTRODUCTION 1

SECTION I - INTERNATIONAL PATENTING PATTERNS, PART II* U.S. vs. FOREIGN INTERNATIONAL PATENTING 7

SECTION II - THE UNIQUENESS OF PATENTS AS A TECHNOLOGICAL RESOURCE 23

Part I - Patents as a Technological Resource 23

Part II - The Patent File as a Technological Resource 38

SECTION III - GEOPHYSICAL EXPLORATION FOR HYDROCARBONS (OIL, GAS AND COAL) 45

Part I - Patent Activity Analysis 49

Part II - Review of Selected Geophysical Exploration Technologies 60

Electrical & Magnetic Prospecting (Examiner Report) 61

Nuclear Geophysical Prospecting (Examiner Report) 72

Gravitational Field Measurement 80

Offshore Seismic Prospecting 82

Seismic Signal Processing (Examiner Report) 84

Seismic Recorders & Displays 98

Borehole Logging 100

Seismic Vibrators 102

Air Guns 104

Solid Explosives 106

Implosive Seismic Wave Generators 108

Gas Exploders 110

Miscellaneous Land Seismic Wave Generators 112

Miscellaneous Marine Seismic Wave Generators 114

---

* For Part I, see the Seventh Report of the Office of Technology Assessment and Forecast. March 1977, pp. 17-30

APPENDIX A - SECTION I DATA TABLES 116

APPENDIX B - OBTAINING PREVIOUS OTAF PUBLICATIONS 121

APPENDIX C - OBTAINING ADDITIONAL INFORMATION OR SPECIAL REPORTS 123

APPENDIX D - ACKNOWLEDGEMENTS 139

# INTRODUCTION*

## Background

The Patent and Trademark Office has assembled one of the largest collections of technological literature in the world--the classified patent search file which contains twenty two million technological documents distributed among 95,000 subdivisions of technology.

Each year about 250,000 new U.S. patent documents are added to this file, along with 280,000 new foreign patents. A sizeable staff is engaged full time in reviewing this file and restructuring it to accommodate new technologies and changes in existing technologies.

In its own unique way, this file represents a national resource; and, the Patent and Trademark Office recognizes its heavy responsibilities not only to preserve, maintain, and improve the file, but, as well, to maximize its use for the greatest public benefit.

It was as part of its effort to discharge this latter responsibility that the Patent and Trademark Office established, in 1971, its technology assessment and forecast program.

In its most general terms, the mission of the program is to stimulate and enhance the use and usability of the patent file, and to assemble, analyze and make available meaningful data about the file. In carrying out this mission, the Office of Technology Assessment and Forecast (OTAF), which administers the program, has assembled and built a master data base covering all U.S. patents. It periodically updates this base and strives continually to add new data items to it. Recent additions to the base are patent application date data, and relationships between the Patent Classification system and the Standard Industrial Classification (SIC) system. This latter addition permits, for the first time, broad scale use of patent data in economic studies. Also added recently, are comprehensive data on pending patent applications and data relating to the patents of other nations.

OTAF uses the data base in two principal ways: First, it periodically issues general distribution publications. These publications have included reports on highly active technological areas; areas experiencing high levels of patenting by foreign residents; profiles of the patenting patterns of the residents of selected foreign countries and U.S. states; reviews of the patent activity of the most active patent assignees; and comparisons of patent activity with economic activity in selected Standard Industrial Classification categories. In addition, several of the publications have examined the patenting in high interest energy technologies.

---

* The material on this and the following page substantially duplicates that presented in previous publications. Those familiar with the Office of Technology Assessment and Forecast and the program it administers, may wish to begin reading on page 3.

A listing of previous OTAF publications and information as to how they may be obtained can be found in Appendix B.

The second principal use of the OTAF data base is made in the preparation of special reports, tailored to individual needs. These reports, which are provided on a cost reimbursable basis, have been utilized by other government agencies and a number of private sector corporations. More information concerning this special report service can be found in Appendix C.

## Patents And Patent Activity

Over four million United States patents have issued since the first was granted on July 31, 1790. To facilitate the use of this large body of technology, these documents have been "classified" (categorized) into more than 300 broad technological groupings (called Classes) and over 95,000 specific technological categories (called subclasses). Together, these Classes and subclasses form the structure of the classified patent file.

Copies of a patent are placed in more than one subclass of this file when the patent contains significant technology pertinent to more than one subclass. With such multiple placement or "cross-referencing" the patent file has grown to contain approximately 11,500,000 U.S. patent documents spanning the entire technological spectrum*.

Since a patent obtained in the United States conveys no protection outside this country, and vice versa, it is common in this age of the "international market place", for inventors to obtain patents in more than one country. As a result, significant foreign inventions are usually patented in the United States because it is such an important market. Thus, U.S. patent activity is representative not only of U.S. technological effort but, to a large extent, of foreign technological effort as well.

For example, the growth of foreign technological capabilities in the 1960's and 1970's has been mirrored by the growth, over the same period, of the share of U.S. patents granted to foreign resident inventors. In 1961, only about 17% of U.S. patents were issued to residents of foreign countries. However, by the end of 1976, the foreign share had increased to over 37%.

This apparent interrelationship between technological and patent activity gave rise to the basic premise of the technology assessment and forecast program - that patent activity is an indicator of technological activity, both domestic and foreign.

---

* The file also contains 9.5 million patents of other nations and over 1 million pieces of non-patent literature.

Patent Data - Use, Meaning and Limitations

Patent data represent a comprehensive, in-depth technological activity information resource. The value of patent data is enhanced by the rarity of quantitative indicators which comprehend the entire technological spectrum and which are available in time series going back to the very beginnings of the United States. Patents, perhaps, are the only such indicator. Consequently, the potential uses of patent data are many and intriguing.

It has been only in recent years, however, that these data have begun to be considered for use to any significant extent. This is the case because patent data, on any but a gross or aggregate basis, have simply not been reasonably available to those who might like to use them.* With the advent of OTAF and its computerized data base, this inhibiting barrier to the use of patent statistics has, to a large extent, been eliminated and workers in many fields have been presented with a new tool.

As a new tool, the parameters of appropriate use for patent-data, its limitations and strong points, have not been well established and are themselves the subject of discussion and study. This is necessary and beneficial. It is one of OTAF's goals to advance and facilitate efforts to learn more about the legitimate implications that can be drawn from patent statistics. It is obvious that in the analysis of these statistics, many factors need to be considered. Among these are the variance between patents in importance and degree of invention. Also, the propensity to patent, as opposed to relying on patent alternatives (e.g., lead time in the market place and trade-secrets) may vary over time within an industry and between industries. These factors and others may well affect any use of, or conclusions drawn from, patent statistics. The more disaggregated the data, perhaps, the more important each of these factors become.

Yet, like the mountain, patent data are "there" and can not (and we strongly believe, should not) be ignored. The data are becoming more available, more detailed, and more useable every year. In the final analysis, it cannot be denied that each patent represents, to some degree, a new piece of technology and, inferentially, some increment of technological activity. Together (in the hundreds, thousands and tens-of-thousands), patents reveal the "who, where and what" about substantial amounts of new technology and technological activity. It seems intuitively obvious then, that clear trends in patenting, especially within a given industry or technology, must be capable of telling us something.

It may be, as some allege, that patenting trends tell us more about the health of the patent system than they do about the health of technology. Or it may be that the trends reveal more about the shifts in domestic tech-

---

* Jacob Schmookler, in his book Invention and Economic Growth (Harvard University Press, 1966) notes on page 21, that a year of effort was invested in the Public Search Room of the U.S. Patent Office collecting the data needed for his studies.

nological development than about the relative balance between domestic and foreign technology. Or maybe they can indeed tell us much about where the U.S. stands overall or in any specific technology as compared to all other foreign countries or to any specific foreign country.

Most probably patent data tell us something about all these things, in some mixture yet to be exactly determined. It will require investigation and study to establish to any widely accepted degree the true meanings of trends suggested by the patent data; but we are confident that the data's comprehensiveness and availability will stimulate this investigation and study.

In the interim, use of the data by OTAF and others for a wide variety of purposes will continue. For just as patents offer substantive technological information available nowhere else*, so do patent data offer a unique indicator of worldwide technological activity -- an indicator which, wisely used, may permit new insight into the complex interactions of technology and the economy.

## About The Contents Of This Publication

This report exemplifies OTAF's interests in all facets of the use of patent information. The three, widely divergent sections of the publication examine patents and patent activity both for the substantive technology disclosed and the implications that can be drawn from the study of patenting as a statistical phenomenon. In addition, the usefulness of patents as a technological information resource is examined.

Section I continues the review of international patenting patterns begun in OTAF's Seventh Report (March 1977). This review involves the use of data relating to patents granted by foreign nations and is made possible through the courtesy and cooperation of Derwent Publications, Ltd., of London, England. Derwent, a private organization which provides information services relating to the international patent literature, has made available to OTAF, for technological activity analysis use, their extensive foreign patent data base.

In Section I, for the first time in an OTAF publication, U.S. origin patenting in foreign countries is examined, as is the balance of patenting between the U.S. and foreign countries in selected Standard Industrial Classification Product Field categories. In addition, technologies most heavily involved in international patenting are identified.

Section II reviews the results of a recently completed OTAF study of the extent to which the technology disclosed in U.S. patents is available in the non-patent literature. Patterned after a similar study of British patents conducted in England, the OTAF investigation was aimed at determining

---

* See Section II of this publication.

the validity of the widely held belief that the bulk of technological information in patents is available, and available sooner in the non-patent literature. The goal was to develop data bearing on the corollary issue -- the uniqueness of the patent file as a resource of technological information.

The OTAF study involved author searches, subject searches and telephone surveys of inventors of a sample of patents from 1967 and 1972. The results, which in some aspects are quite different from those of the British study, show a wide divergence of publication rates between technologies. However, the implications of both the OTAF and British studies are essentially the same -- a very large amount of technology is disclosed only in patents.

Also presented in Section II is a review and the results of a joint project involving OTAF, the Universal Oil Products Co. and the American Chemical Society. The project was designed to "test", in two, limited areas of technology, the usefulness of the patent file to provide pertinent technological information not available elsewhere.

Section III presents an assessment of the activity in technologies relating to geophysical exploration for hydrocarbons (oil, gas and coal). One of the more extensive treatments of a technological area presented in an OTAF publication, the review presents a general analysis, reports by patent examiners in their areas of expertise and a series of "mini-reports" -- brief surveys of patenting trends and recent activity in technologies which are components of the overall area.

Like the extensive review of computer memory technologies (Seventh Report - March 1977), this analysis of energy resource exploration patenting is aimed both at presenting significant substantive information about the subject technology, and at creating an awareness of and stimulating an interest in the potential of patents as a source of technological information.

The publication concludes with four appendices. Appendix A contains tables of data relating to Section I. Appendix B lists and briefly describes previous OTAF publications and gives information on how they may be obtained. Appendix C gives information about OTAF's special report services and includes excerpts from samples of three "standard type" special reports. Appendix D names and acknowledges the assistance of the many Patent and Trademark Office personnel who have contributed to this publication.

# SECTION I

## INTERNATIONAL PATENTING PATTERNS, PART II*
## U.S. vs. FOREIGN INTERNATIONAL PATENTING

### Background

The first six publications of the Office of Technology Assessment and Forecast (OTAF), in their use and analysis of patent data, relied almost exclusively on patents granted by the United States. Foreign patent activity was reviewed only in terms of U.S. patents granted to foreign residents. Since a significant percentage of U.S. patents is issued to foreign resident inventors (over 37% in 1976), and since the U.S. is such an important market, it is believed that this technique has yielded, and will continue to yield, useful information about foreign technological activity. From its inception, however, OTAF recognized the desirability of adding to its data base, data concerning the patents granted by other nations.

The U.S. Patent and Trademark Office receives copies of nearly all available foreign patent documents. These are used by U.S. patent examiners in determining the novelty of inventions for which patents have been applied. Because of the very large number of foreign patent documents printed and since many are duplicative, i.e., form a "family of patents"**, the processing and eventual inclusion of unique documents in the examiner's search files is a complex process for which complete data have not been maintained.

However, in 1976, through the courtesy and cooperation of Derwent Publications, Ltd. of London, England, OTAF obtained the Derwent data base for patent activity analysis use. Derwent is a private organization which provides various kinds of information services relating to patents issued

---

* For Part I see the Seventh Report of the Office of Technology Assessment and Forecast, March 1977, pp. 17-30.

** It is common to seek patent protection on a single invention in several countries (a patent is enforceable only in the country that grants it). This multiple patent application filing results in the issuance of several patent documents, each from a different country, but all to the same invention. These patents form a "family". International multiple patenting has been facilitated by a treaty which permits applications filed in a foreign country within a year of filing in the home country to be accorded the home country filing date.

However, the treaty requires that, in order to receive the earlier filing date, the initially filed patent application must be identified by country, serial number and filing date, and that the "priority" of this filing be claimed. This "priority" information is printed on all published patent documents in the "family" and permits the members of a family to be identified, allowing duplicate patent document elimination by patent offices seeking to avoid unnecessary search file growth. In this Section the "priority" country (i.e., the country in which the original patent application, forming the base of the "family", was filed) is assumed to be the country of origin of the invention.

throughout the world. Beginning in the 1960's with chemical and pharmaceutical technologies, coverage by their data base gradually has been expanded and now includes extensive information on the patent documents in all technologies, of some 24 countries. This present coverage (listed in Table 1-1, below has captured the preponderance of the world's patent documentation in recent years.*

Table 1-1: Derwent Coverage -

| | | |
|---|---|---|
| Argentina | France | Portugal |
| Austria | German Dem. Rep. | Romania |
| Belgium | Germany, Fed. Rep. | S. Africa |
| Brazil | Hungary | Sweden |
| Canada | Israel | Switzerland |
| Czechoslovakia | Japan | United Kingdom |
| Denmark | Netherlands | United States |
| Finland | Norway | U. S. S. R. |

In the Seventh Report (March 1977), first use was made in an OTAF publication of data extracted from this base. The distribution, by source country, of inventions first published in the 1975 patent literature was reviewed, both overall and on a technological basis (using the International Patent Classification system). In addition, those subclasses of the U. S. Patent Classification System which contained the highest number of patents involved in international patenting (during the period covered by the Derwent data base) were identified.

In this section, use of the Derwent data base for international patenting analysis is continued. The focus of this analysis is the body of technology represented by all inventions patented in the United States in 1975. There were several reasons for selecting this particular "universe".

First, it is a goal of this analysis to review the balance of patenting between the U. S. and other countries. Consequently, with the U. S. the "hub" of the international patenting to be studied, a body of technology defined in terms of an identifiable grouping of U. S. patents seemed appropriate. Second, the processes leading to patent publication vary greatly throughout the world -- from detailed examination systems, as in the U. S., to simple registration procedures. Thus the selection of a universe of U. S. patents ensures that the body of technology covered meets established levels of "newness".

Third, time must be allowed for patent families to develop. The first indication to OTAF of a U. S. origin, foreign patent document**, for example,

---

* Derwent is not the only organization which collects international patenting information. Other organizations, such as the International Patent Documentation Service (INPADOC) in Vienna, Austria, maintain extensive foreign patent data bases, as well.

** The term patent document is used throughout the Section because, in addition to patents, other documents, such as published patent applications (e.g., from Belgium) and inventors' certificates (e.g., from the U. S. S. R.) are included, as well.

is the publication of that document and its capture on the Derwent base. Since the period from application filing to patent document publication varies substantially between countries (from a few months to several years), the selection of U.S. patents issued in 1975 was necessary for reasonable assurance that the families related to those patents were complete. Fourth, 1975 was the first year Derwent had substantially comprehensive coverage of patent documents in all technologies for the countries covered in this review.

U.S. Patenting - Domestic and International

In the "pie graph" below (Figure 1-1), the distribution of the nearly 72,000 patents granted by the United States in 1975 is shown in three categories:

- U.S. origin, domestic only patents: 1975 U.S. patents shown on the Derwent data base to stem from a patent application first filed in the U.S., and, at the time data for this report were collected, not to have been the subject of patent documentation in any other country.

- U.S. origin international patents: 1975 U.S. patents shown on the Derwent data base to stem from a patent application first filed in the U.S. and to have been the subject of patent documentation in at least one country other than the U.S.

- Foreign origin international patents: 1975 U.S. patents shown on the Derwent data base to stem from a patent application originally filed outside the U.S.

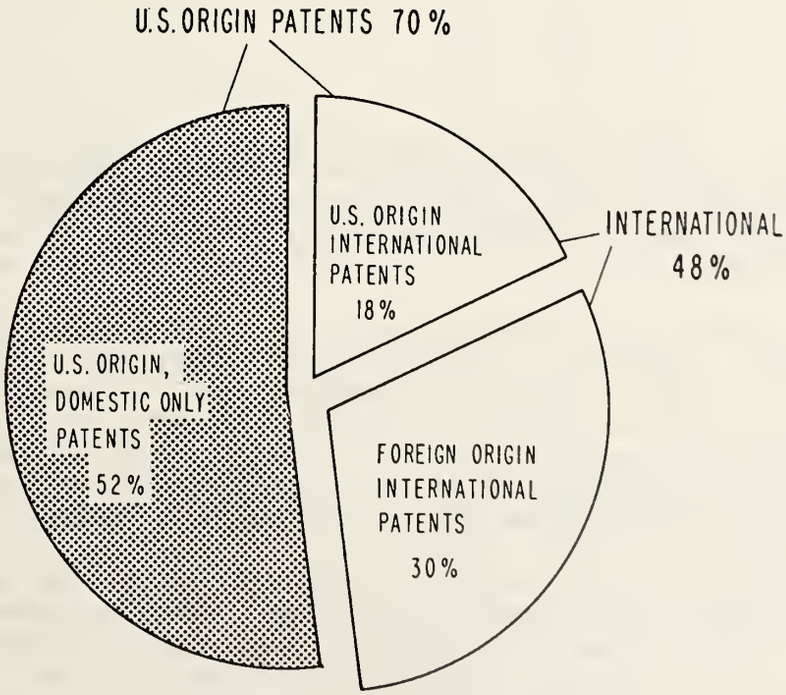



FIG. 1-1 · 1975 DOMESTIC AND INTERNATIONAL U.S. PATENTING, BY ORIGIN

Almost one of every two U.S. patents granted in 1975 was the subject of international patenting -- 18% of the 1975 patents being international of U.S. origin and 30% being international of foreign origin*. Looking at all 1975 U.S. origin patents, as a group, nearly one in four was patented multinationally. Considering the high costs of patenting an invention in several countries, this appears to be a substantial ratio.

Examining the nearly 22,000, 1975 U.S. patents which were internationally filed and which were of foreign origin, one finds over 75 different countries represented. Yet, only two countries, Japan and the Federal Republic of Germany, account for half of these patents. Add two more countries, the United Kingdom and France, and about 75% of the 1975 foreign origin U.S. international patents are accounted for.

In Figure 1-2, the overall data of Figure 1-1 is disaggregated into major areas of technology. The 1975 U.S. patenting is divided into the three broad disciplines -Electrical, Chemical and Mechanical -and each of these is subdivided into the categories of domestic only, U.S. origin international, and foreign origin international patenting. The relative length of a bar indicates that discipline's share of total patenting. As can be seen, patents to mechanical inventions dominate, being more numerous than the other two combined.

---

* Those familiar with U.S. patent statistics will note a discrepancy between the previously published figure of 35% of 1975 U.S. patents having been of foreign origin, and the 30% figure shown in the "pie". This difference arises because different methods are used to arrive at the two figures.

In categorization for statistical purposes, the Patent and Trademark Office considers a U.S. patent to be of foreign origin if the first named inventor is a non-U.S. resident. This is the definition which, in general, is used by OTAF. However, in this Section, which relies on the Derwent data base, the categorization is based on country of origin of the patent application from which the U.S. patent stems, i.e., the "priority country". (See footnote on first page of this Section for explanation of priority.)

What the difference between the two figures means, is that in 1975 about 5% of U.S. patents were granted to foreign country residents who either had not first filed a patent application in their home country or who had filed such an application more than one year prior to the filing of their U.S. application and, consequently, could not claim "priority" for the first application.

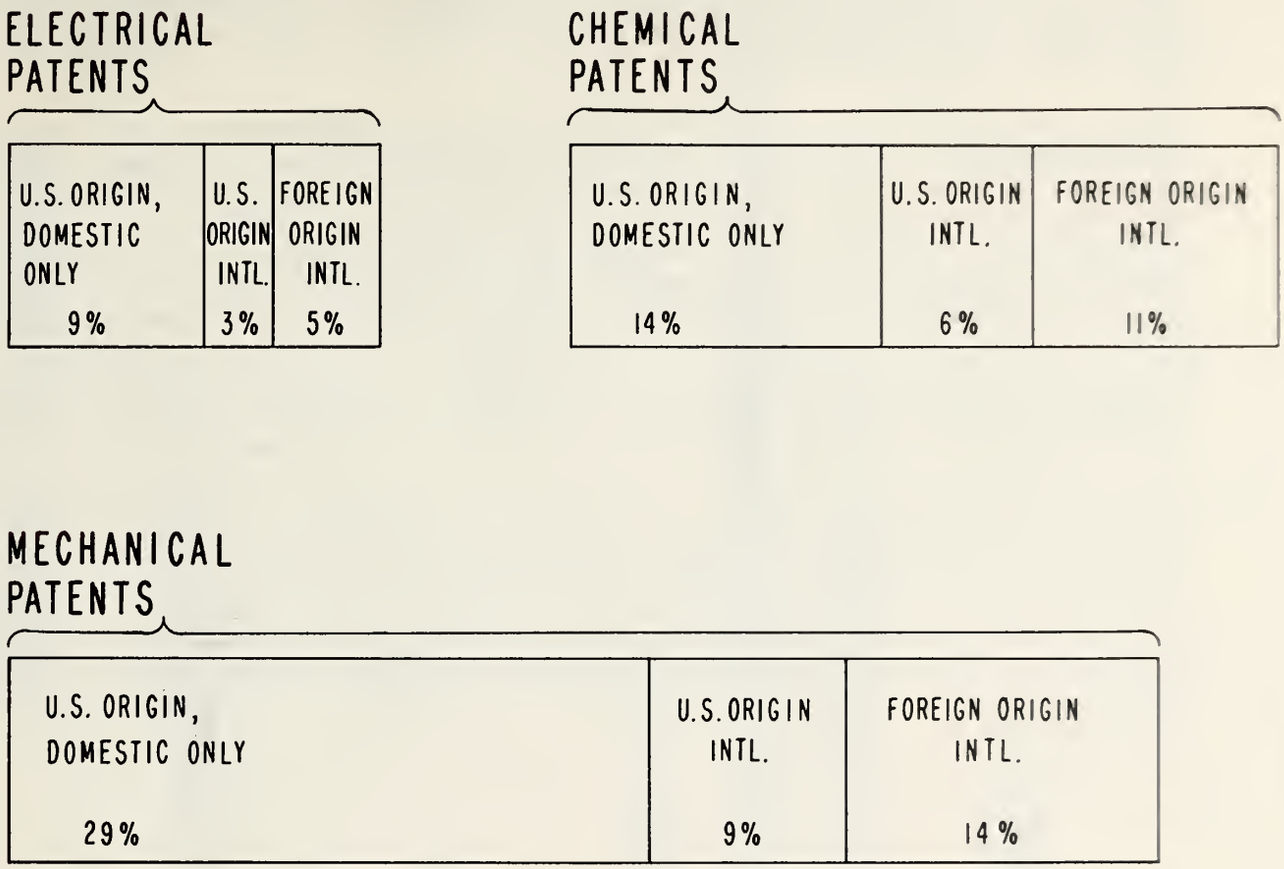



FIG. 1-2: 1975 DOMESTIC AND INTERNATIONAL U.S. PATENTING, BY DISCIPLINE AND ORIGIN

Within each discipline the proportion of patents which were U.S. origin and which were involved in international patenting is, essentially, the same (i.e., 18% of Electrical, 19% of Chemical and 17% of Mechanical). This consistency does not hold true, however, for the foreign origin international, which is 35% of Chemical, as opposed to 29% and 27% of Electrical and Mechanical, respectively, indicating a somewhat heavier concentration of foreign activity in chemical technologies.

More detail can be obtained by reference to Figure 1-3 on the next page where the 1975 patenting is distributed among 12 broad Standard Industrial Classification (SIC) Product Field categories (and an "All Other" category). OTAF's capability to prepare such a distribution stems from the development, with National Science Foundation support, of a concordance between the U.S. Patent Classification System and some 55, two and three digit level SIC Product Fields*.

In general the graph** tends to conform to the distributions shown in the more aggregate, Chemical, Electrical and Mechanical groupings -- the greatest activity being in the Mechanical Product Fields (e.g, Machinery), the highest percentage of foreign activity being in Chemicals & Allied Products***, etc. However, certain anomalies do appear. For example, there is the rather low (in comparison to the general average) U.S. international activity in Transportation Equipment. In one of the two smallest areas, Petroleum & Natural Gas Extraction and Petroleum Refining, the foreign international activity is less than half the average for all the Product Fields combined. Yet, in the other of the two smallest areas, Textile Mill Products, foreign international patenting is higher than average.

An interesting aside, is that, in terms of percentages, the category which experienced the most U.S. origin international patent activity was SIC 357 (not shown on the chart), Office Computing & Accounting Machines, e.g., computers. There were about 2500, 1975 U.S. patents in this category of which 24% were U.S. origin international. The foreign origin international in the category was 30% (about average) and the balance (46%) were "domestic only" patents, i.e., to inventions not patented outside the U.S.

---

* For more information about the development of this concordance, the reader is referred to OTAF's Fifth Report, August 1975.

** The reader should note that totals for the Product Fields shown will sum to a figure higher than the number of U.S. patents issued in 1975. This occurs because a patent, disclosing an invention with more than one utility (e.g., a bearing assembly useful in both transportation equipment and in machinery), would be found in more than one category.

*** SIC 28, Chemicals & Allied Products is more limited than the broad "Chemical" grouping. The latter, for example, includes oil and grease compositions which would be found in SIC 29.

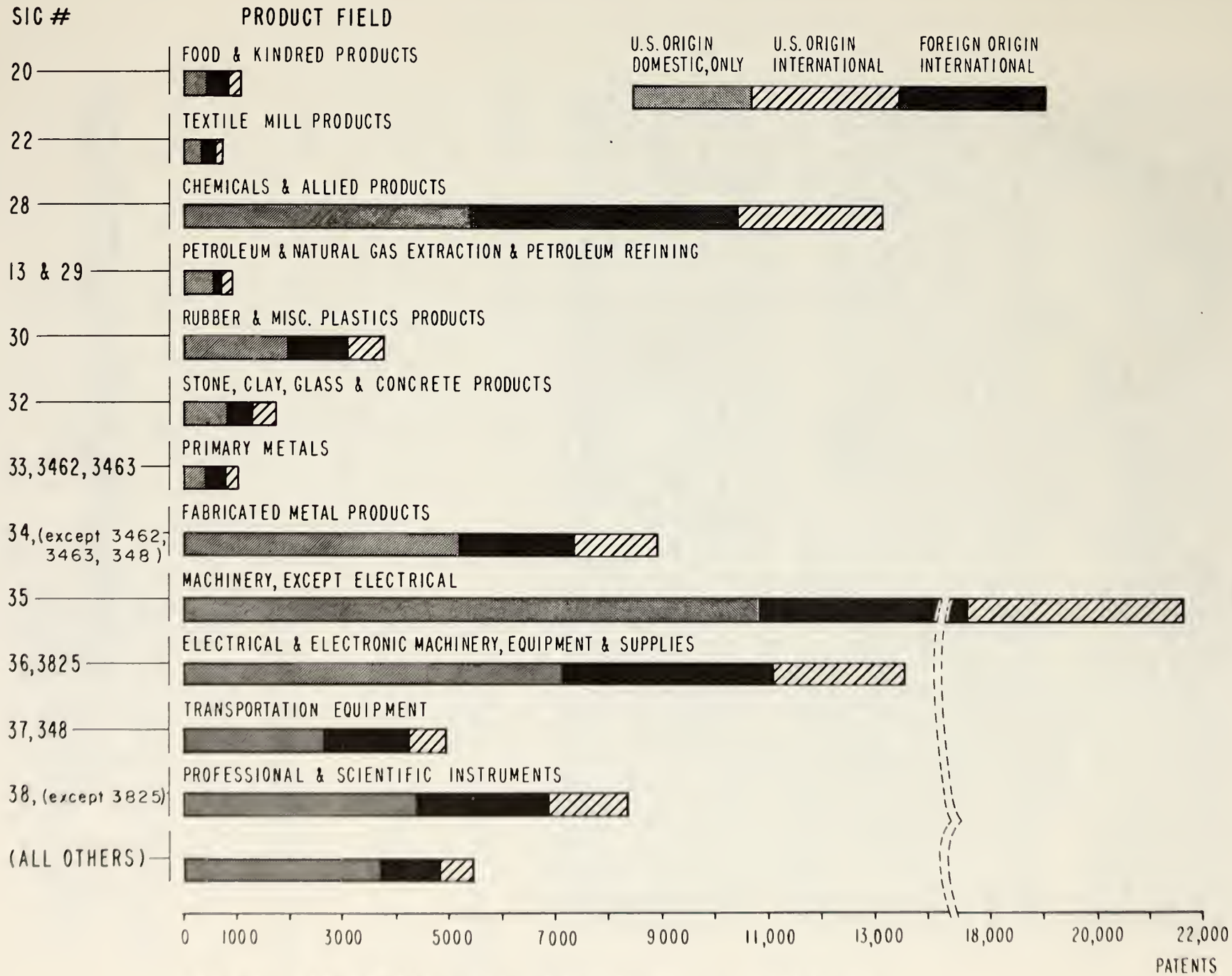



FIG. 1-3 1975 DOMESTIC AND INTERNATIONAL U.S. PATENTING, BY SIC PRODUCT FIELD AND ORIGIN

For a deeper level of investigation into the specific technologies most involved in international patenting, attention will now be turned to those specific U.S. Patent Classification system subclasses* which, in terms of their 1975 U.S. patenting, received the highest percentages of international patents. Certain criteria were used to eliminate small and/or inactive subclasses. To be considered for selection, a subclass had to have a minimum of 100 patents and must have received at least 15 patents in 1975.

Thirty subclasses were selected, ten from each of three broad disciplines -- Electrical, Chemical and Mechanical. The resulting list (presented in Table 1-2) is quite different from the internationally active subclasses given in OTAF's Seventh Report. The principal reason is that, in the Seventh Report, the data used were extracted from the entire Derwent data base. Consequently, due to Derwent's coverage only of Chemical related technologies through the 1960's and the early 1970's, the subclasses appearing as most active internationally were heavily weighted toward the chemical arts. In this Section, however, by limiting the patenting data to 1975 (when Derwent's coverage had been broadened to all technologies), a more balanced subclass listing was obtained.

A review of Table 1-2 indicates the wide variety of technologies which are heavily involved in international patenting. In order to illustrate this variety and still limit the table to 10 subclasses from each discipline, some high international subclasses were omitted which otherwise would have been listed. For the most part, these omitted subclasses related to technologies represented by those listed. For example, several additional subclasses relating to pumps and fuel injection devices for diesel engines had international patenting activity equal to those listed in the table. A similar situation existed for subclasses in textile weaving and spinning technologies, in photoelectric controls for cameras and in electric motors.

---

* The U.S. Patent Classification system is made up of over 300 major "Classes" which are further divided into about 95,000 subdivisions of technology, called subclasses.

Table 1-2. SUBCLASSES WITH HIGHEST LEVEL OF INTERNATIONAL PATENTING IN 1975

-ELECTRICAL-

| Class/ Subclass | Percent Int. | Percent For. Int. | Technology |
|---|---|---|---|
| 174/15C | 93.3 | 86.7 | Fluid cooled electrical cables and joints |
| 178/68 | 93.3 | 40.0 | Telegraphy-pulsating current systems |
| 178/69.5TV | 88.9 | 55.6 | Television synchronizers |
| 346/75 | 88.4 | 37.2 | Ink jet printing |
| 219/125R | 86.7 | 53.3 | Arc welding with automatic positioning of arc |
| 340/173FF | 86.7 | 46.7 | Signal storage using flip-flop storage cells |
| 318/138 | 84.2 | 76.3 | Electric motors with space discharge device commutation |
| 315/151 | 82.4 | 70.6 | Radient energy (e.g., light) control responsive to energy source intensity |
| 340/58 | 82.4 | 64.7 | Vehicle electrical systems which automatically indicate a deflated tire condition |
| 357/90 | 81.8 | 59.1 | Active solid state devices with concentration gradient |
| | | -CHEMICAL- | |
| 204/58 | 93.8 | 68.8 | Electrolytic methods for coating aluminum based metals |
| 260/37NP | 93.8 | 93.8 | Melt spun synthetic resins containing dyes and pigments |
| 75/58 | 90.0 | 65.0 | Purification of molton iron using solid metals or metalloids in an elemental state |
| 96/100 | 90.0 | 80.0 | Silver based photographic compositions containing processing ingredients and dyestuffs |

| Class/ Subclass | Percent Int. | Percent For. Int. | Technology |
|---|---|---|---|
| 260/346.4 | 88.9 | 77.8 | Polycarboxylic acid anhydride production from oxidation of aromatic compounds |
| 195/36R | 86.7 | 60.0 | Production of carboxylic acids or salts by mold fermentation of carbohydrates |
| 424/33 | 86.7 | 66.7 | Pharmaceutical compositions and their preparation having a polyethylene coating |
| 8/54.2 | 86.4 | 81.8 | Processes and compositions for dyeing cellulose fibers |
| 252/520 | 84.2 | 63.2 | Electrically conductive or emissive compositions containing titanium or zirconium compounds |
| 260/308A | 84.2 | 79.0 | 1,2,3,-triazoles and their preparation |
| | | -MECHANICAL- | |
| 123/139E | 100.0 | 81.8 | Electric pumps for diesel engines |
| 57/58.89 | 97.1 | 88.6 | Free end yarn spinning devices |
| 72/21 | 93.8 | 81.3 | Metal deforming machines with controls responsive to tool condition |
| 354/60R | 91.7 | 87.5 | Circuits for photoelectric devices in cameras |
| 432/106 | 88.9 | 72.2 | Rotary drum furnaces with plural work chambers in series |
| 303/21AF | 86.4 | 70.5 | Fluid pressure brakes with control systems responsive to speed and brake failure |
| 293/88 | 83.3 | 66.7 | Vehicle bumpers with rubber mounts |
| 350/214 | 82.6 | 78.3 | Multiple component lens systems |
| 58/85.5 | 81.8 | 68.2 | Watches with time setting mechanisms |
| 29/599 | 81.3 | 68.8 | Processes for making superconductors |

It is interesting to note that, with the exception of two areas in the electrical group -- telegraphy, pulsating current systems and ink jet printing -- the foreign origin international patents exceeded the U.S. origin international. This gives the impression of a sharp deficit in the balance of international patenting between the U.S. and foreign countries. This is true only if one considers the issue in the limited context of U.S. patents. To more completely comprehend the balance of patenting situation, one must examine U.S. origin patenting in other specific countries.

## Patent Balance

In this portion of the Section, the U.S. vs. foreign international patenting relationship is studied on a specific country basis. Considered is the number of patents from and to the U.S. and 10 other major countries. Where previous figures and Table 1-1 considered all foreign country patenting under one heading (Foreign International), the "patent balance" calculated here shows the one-on-one relationship of the U.S. to specific foreign countries.

The major foreign countries selected for analysis are: Belgium; Canada; Switzerland; United Kingdom; South Africa; Netherlands; German Democratic Republic; Federal Republic of Germany; France; and, the U.S.S.R. Unfortunately, Japan is not among them. This omission is dictated by the fact that Derwent (and, consequently, the Derwent data base) does not yet cover all Japanese patent documents in all technologies. As a result, available data for Japan are incomplete and this admittedly important industrial nation had to be excluded from the following analysis.

The results, giving the overall balance of international patenting between the U.S. and each of the 10 countries (plus all others combined, excluding Japan), are shown in Figure 1-4 on the following page.*

---

* In this portion of the Section the focus of the analysis is still the body of technology represented by all inventions patented in the United States in 1975. However, an "international patent" is defined as one which is the subject of patent documentation in more than one country. This is somewhat different from the definition used in the first portion of the Section where "foreign origin international" included those U.S. patents which had a foreign priority, even though no patent document, other than a U.S. patent, was indicated as having yet been published on the invention.

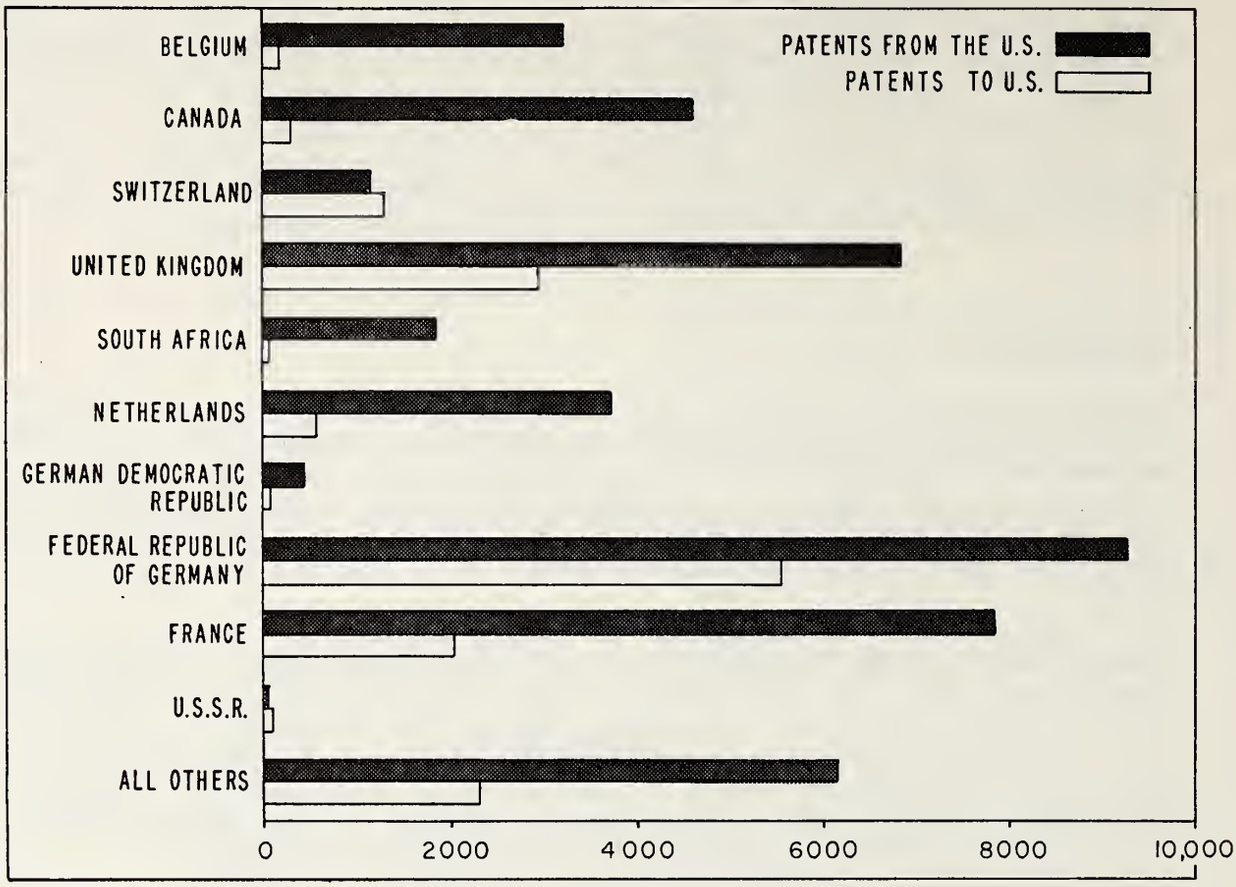



FIG.1-4: PATENT BALANCE: U.S. VS. SELECTED COUNTRIES (ON INVENTIONS PATENTED IN THE U.S. IN 1975)

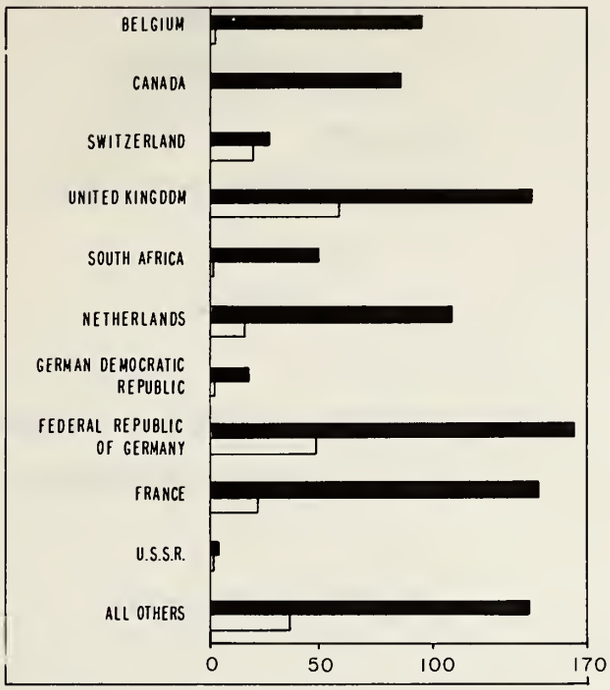
Looking at the U.S. vs. foreign origin international patenting relationship on a "by country" basis, gives a substantially different picture than when the relationship is considered in the aggregate. In the latter (treated in the first portion of the Section), the U.S. clearly appears at a disadvantage. However, as Figure 1-4 shows, when the U.S. vs. foreign patent balance is viewed bi-laterally, the U.S. has a "positive balance" (more of a foreign country's patents than that country has U.S. patents) for all but two countries -- Switzerland and the U.S.S.R.*

A somewhat more informative picture emerges when the patent balance data are distributed on a technological basis. In Figure 1-5, the balance of patenting between the U.S. and each country represented in Figure 1-4, is shown for each of the SIC Product Field categories used in Figure 1-3.

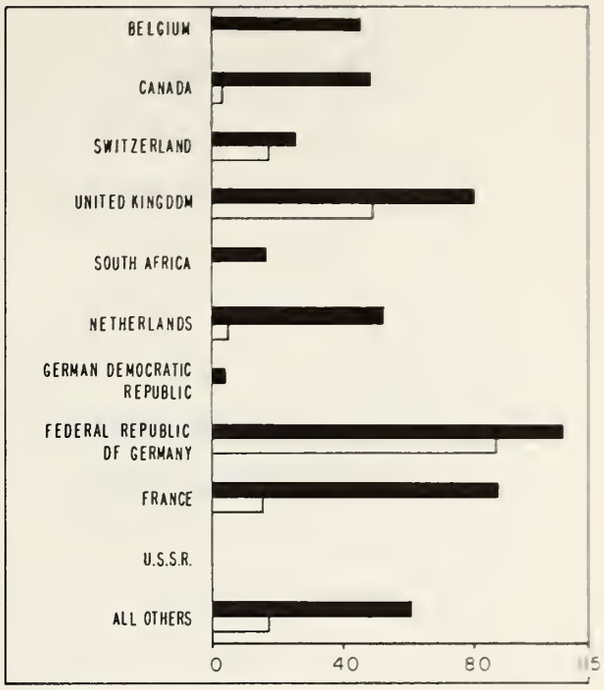
---

* The many U.S./U.S.S.R. trade and technology exchange limitations that exist severly limit the meaningfulness of cross patenting as an indicator of the overall relative technological position between the two countries. However, on a micro basis, patents can be a useful tool in assessing relative progress in some specific technologies.

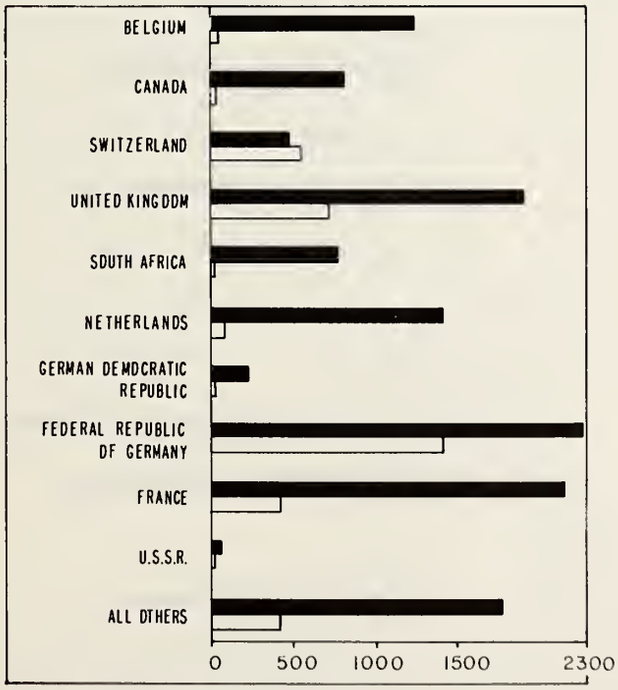
# FIG. I-5: PATENT BALANCE BY SIC PRODUCT FIELD: U.S. vs. SELECTED COUNTRIES (ON INVENTIONS PATENTED IN THE U.S. IN 1975)



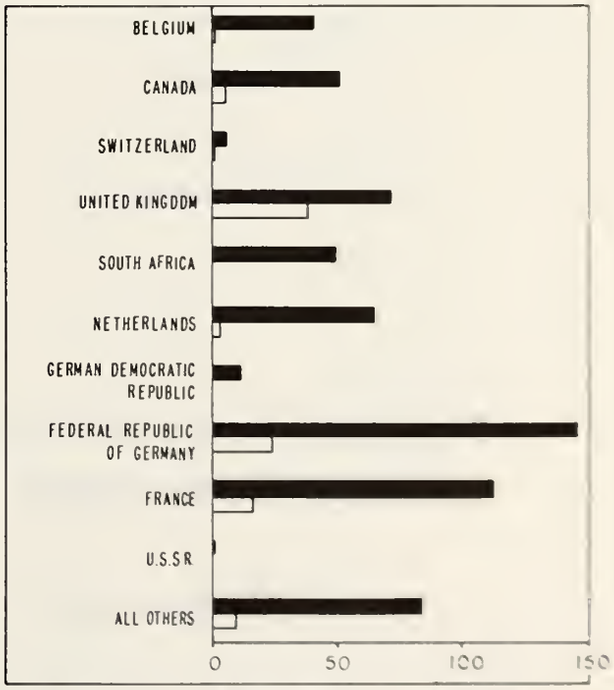

SIC 20 FOOD & KINDRED PRODUCTS




SIC 22 TEXTILE MILL PRODUCTS



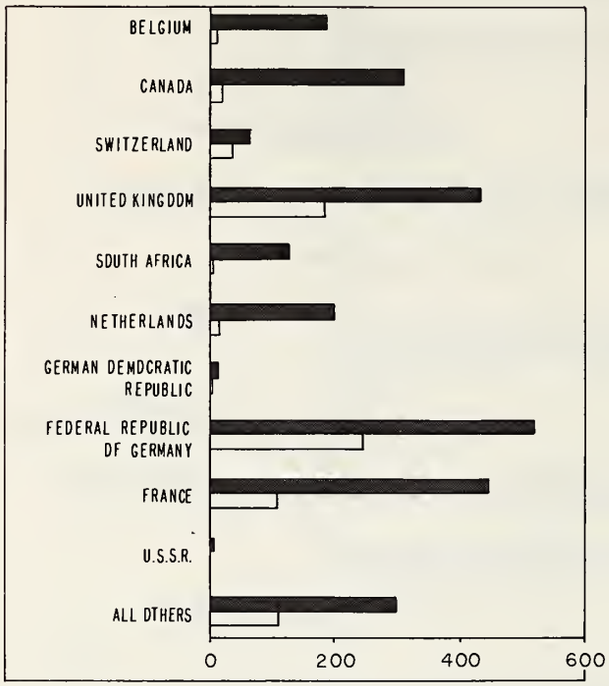

SIC 28 CHEMICALS & ALLIED PRODUCTS



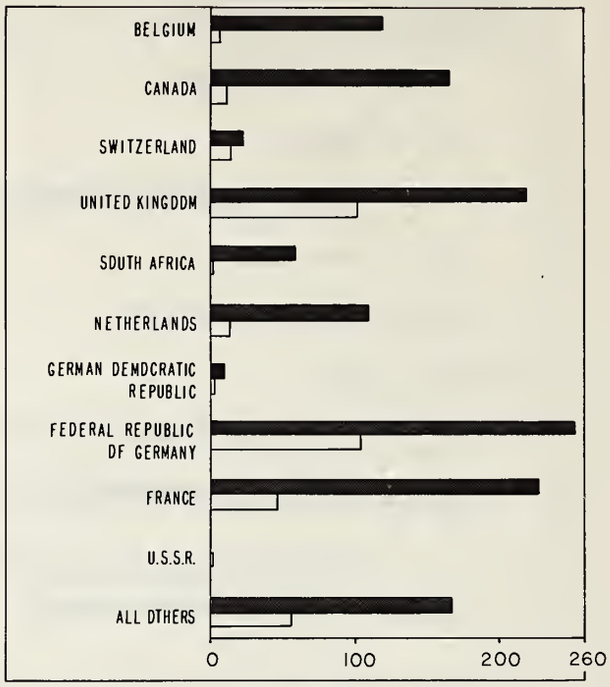

SIC 13 & 29 PETROLEUM & NATURAL GAS EXTRACTION & PETROLEUM REFINING

PATENTS FROM THE U.S. ■
PATENTS TO U.S. □

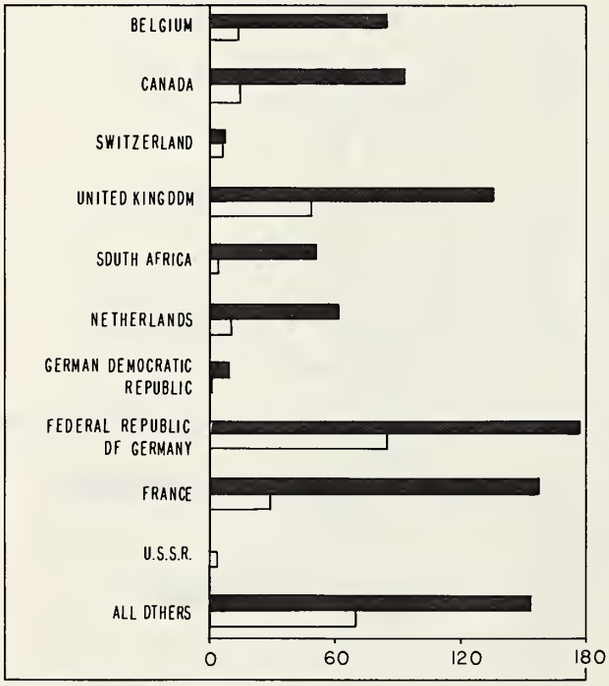
FIG. I-5 (CONT.)



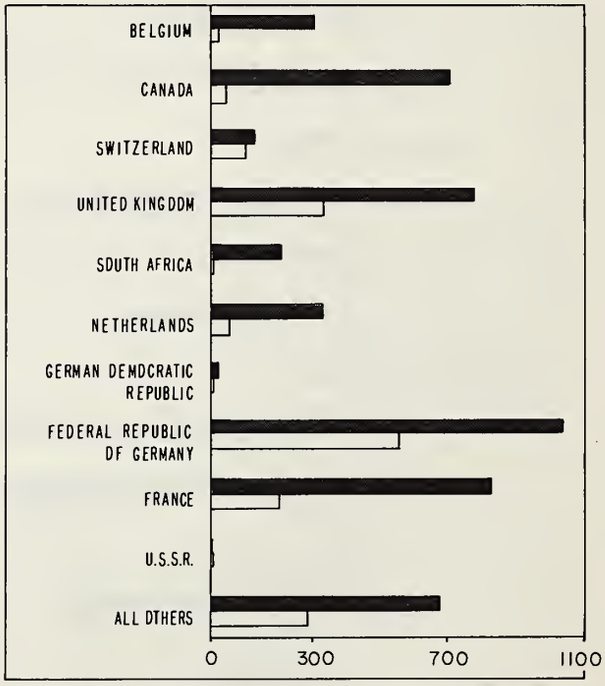

SIC 30 RUBBER & MISCELLANEOUS PLASTICS PRODUCTS




SIC 32 STONE, CLAY, GLASS & CONCRETE PRODUCTS



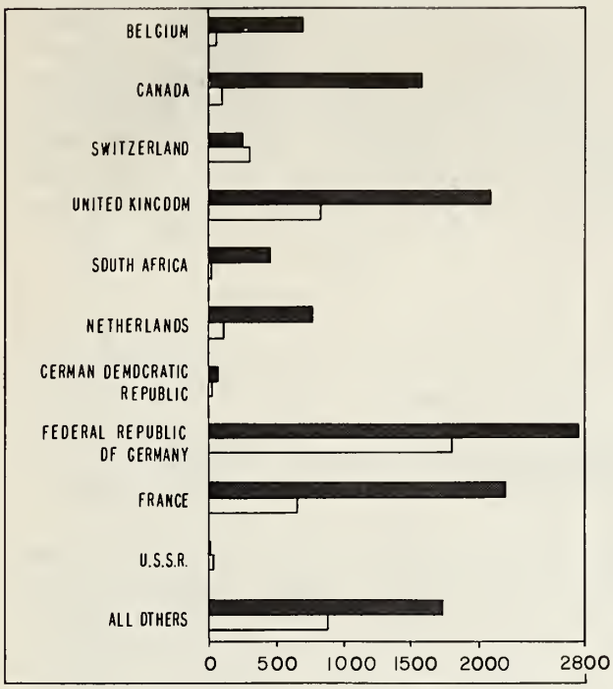

SIC 33, 3462, 3463 PRIMARY METALS



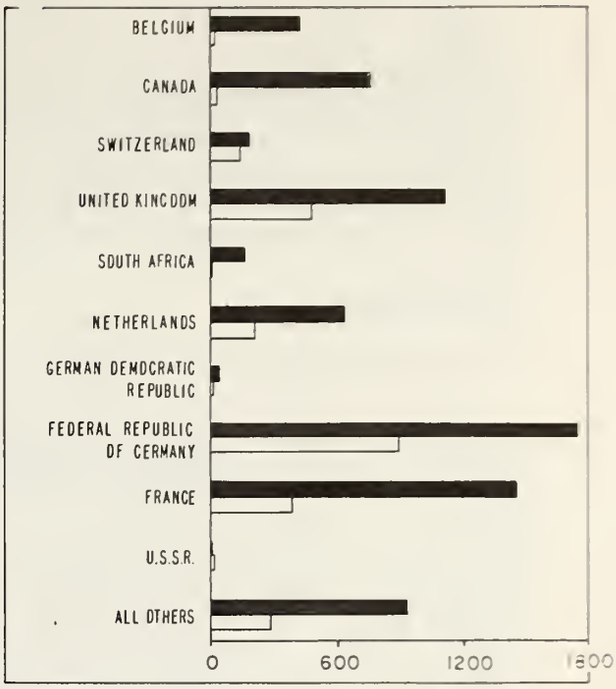

SIC 34 (EXCEPT 3462, 3463, 348) FABRICATED METAL PRODUCTS

PATENTS FROM THE U.S.
PATENTS TO U.S.

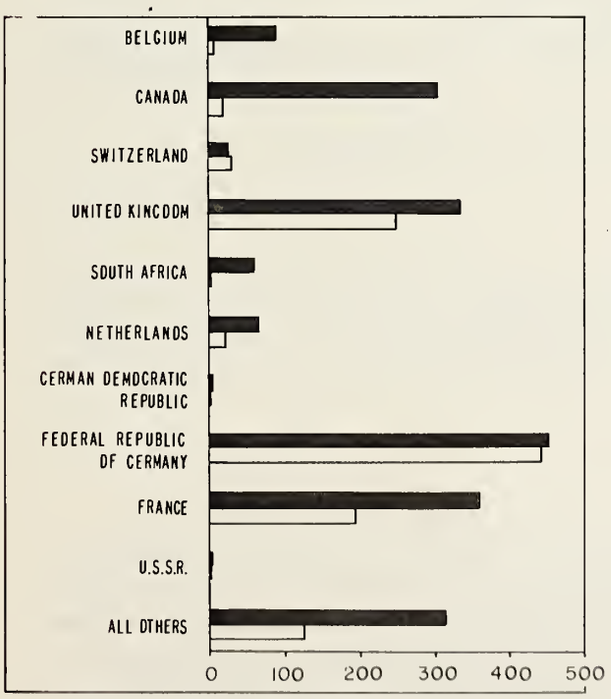
FIG. I-5 (CONT.)



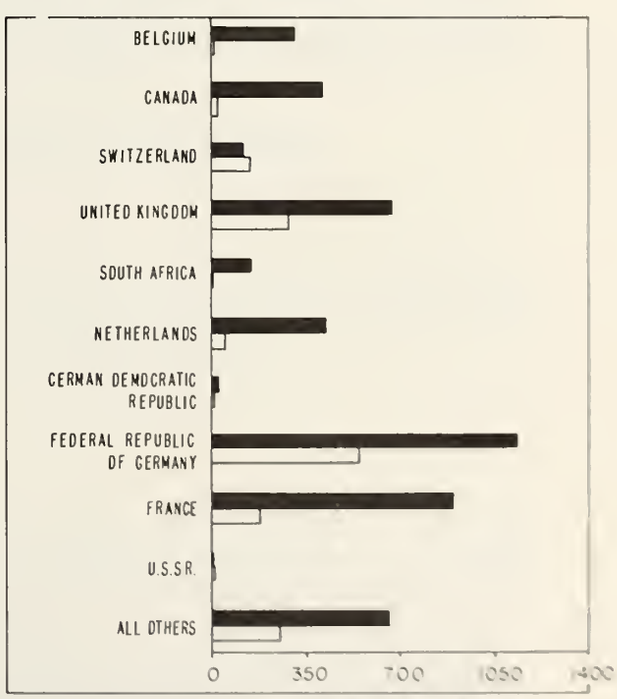

SIC 35 MACHINERY, EXCEPT ELECTRICAL




SIC 36, 3825 ELECTRICAL & ELECTRONIC MACHINERY, EQUIPMENT & SUPPLIES




SIC 37, 348 TRANSPORTATION EQUIPMENT




SIC 38 (EXCEPT 3825) PROFESSIONAL & SCIENTIFIC INSTRUMENTS

PATENTS FROM THE U.S.
PATENTS TO US

As the distributions in Figure 1-5 reveal, the negative U.S./Switzerland patent balance, shown in Figure 1-4, was not present across all Product Fields. In only four of the 12 Fields illustrated did Swiss priority applications account for more U.S. patents than did U.S. priority applications account for Swiss patents. Those Fields are Chemical and Allied Products; Machinery, except Electrical; Transportation Equipment; and Professional and Scientific Instruments. With these exceptions (and those for the U.S.S.R.), the U.S. had a positive patent balance with all countries and for all Product Fields shown.*

Conclusion

The results show that, for 1975, the U.S. maintained a positive patent balance with most of the major industrialized nations of the world -- Switzerland and the U.S.S.R. being the only exceptions.** Even with these two, where the U.S. has a negative overall patent balance, a positive patent balance was experienced by the U.S. in many specific technologies.

While this is an important result, especially in light of the widely held view that U.S. origin patenting is declining, perhaps the major result of this study is the demonstration of the need to look at patent data on a disaggregated level. An observer of Figure 1-1 or even 1-2, which compare overall patenting and patenting in major disciplines, might conclude that the U.S. had a negative patent balance. The disaggregated data, by country and specific product field, generally show otherwise.

---

* Recognizing that there may be interest in the patent balance relationships in all 55 Product Field categories for which data are available, a complete table is given in Appendix A.

** Due to a lack of data, as previously explained, the U.S./Japan patent balance could not be determined.

# SECTION II

## THE UNIQUENESS OF PATENTS AS A TECHNOLOGICAL RESOURCE

This section reports the results of two studies which attempt to measure the value of patents and the patent file as a technological resource. The first of these - Patents as a Technological Resource - seeks an answer to the question: How much technology disclosed in patents is reported in the non-patent literature[1]? If patented technology is not disclosed to any appreciable extent in the non-patent literature, a case can be made that patents are a unique and valuable technological resource which must be considered in any search for technological information. Analogous in design to a study of British patents[2], the project employs a random sample of 435 U.S. patents; each of which was extensively searched in the non-patent literature.

The second study - The Patented File as a Technological Resource - addresses the question: How much technology disclosed in the patent file can be accessed outside of the Patent and Trademark Office? It seeks to determine the value, as a technological resource, of the Patent and Trademark Office's extensive categorized collection of patents (the patent file). This study involved search efforts by the Universal Oil Products Company (UOP) and the Office of Technology Assessment and Forecast (OTAF), which were reviewed by the American Chemical Society (ACS). Two areas of technology were searched - "Non-lead Antiknock Additives for Gasoline" and "Nitrogen Fixation Methods". For each area, UOP utilized whatever search resources they had available, while OTAF examined pertinent U.S. Patent Classifications (subclasses) within the Examiner search files. The two searches were then compared and analyzed by ACS for similarities and differences in results.

### I. PATENTS AS A TECHNOLOGICAL RESOURCE

Background

Patents record almost all advances of technology, large and small. Thus, they are a ready source of information on both past and recent developments in technology. In spite of these attributes, many information workers consider patents to be an information resource of last resort.

---

1 Non-patent literature is defined for the purpose of this study as all publications except references to patents, abstracts of patents or foreign equivalents. (Inventions are often patented in several countries. Thus, U.S. patents may have foreign patent equivalents.)

2 Liebesny et al, The Scientific and Technical Information Contained in Patent Specifications - The Extent and Time Factors of its Publication in Other Forms of Literature, The Information Scientist, December 1974, pp 165-177.

This view is reflected in a 1966 study for the National Aeronautics and Space Administration by J. S. Gilmore of the Denver Research Institute[3]. He attempted to identify the means by which industries become aware of new advances in technology. Five different industries were surveyed, both by questionnaire and interview. The use of patents was quite low compared with the use of other information sources. "On a scale of 100, patents ranked 5 for usefulness in both 'awareness' and 'problem solving', while trade and professional journals, meetings, supplier personnel and vender catalogs ranked above 30 in nearly every instance." Even persons who were oriented toward research ranked patents at only 9. The study also mentions, however, that "patent literature although not widely used, was highly valued, both for the specific and detailed technical information it contained and for that portion of a patent application which surveyed the state of the art."

A second study, "Cost Effectiveness of Information Systems" by the American Chemical Society[4], deals with another population, industrial chemists, and shows a higher use of patents. Of the chemists surveyed, 84% had patent services available and of these, 68% made use of patent services for either current awareness or searching. The availability and use of patents found in this study suggests that patents do indeed offer the industrial chemist a valuable service and confirms, somewhat, the perception found in Gilmore's study, that patents have great value.

The above studies show that the degree of use is to some extent dependent on who the user is and his or her location. Patents appear to be used more in large industrial organizations than in small industrial organizations. In universities or colleges where matters of patent protection often have little importance, patents appear to be little used. Particularly in this setting, their use does not seem to be as widespread as that of journals or abstracting services.

There are many possible reasons for the meager use of patents. Researchers may be hindered by a lack of awareness of the kind of information which patents contain or of how to obtain patent literature. Other difficulties for researchers may stem from features of the patent system. The information in the patent may be outdated as a result of the delay between the development of the invention and its acceptance and publication as a patent. In addition, the inefficiencies in such secondary patent literature as abridgements and the structure of the indices to patents hinders certain types of searches. Also, the peculiar language in which patents are written is difficult for researchers to read. Furthermore, the relative inaccessi-

---

3 John S. Gilmore et al, The Channels of Technology Acquisition in Commercial Firms, and the NASA Dissemination Program, Denver Research Institute, June 1967, NASA CR-790

4 N. B. Hannay et al, Cost Effectiveness of Information Systems, Subcommittee on the Economics of Chemical Information, Committee on Corporation Associates, American Chemical Society, May 1969.

bility of patents, particularly foreign patents, in which an unknown language may be a further hindrance, promotes a tendency in the researcher to ignore the patent literature. The problems mentioned so far may be alleviated, to an extent, by the education of the researcher to the patent system so as to render its information more readily available.

Finally, potential patent users may believe that the information contained in patents will eventually come to their attention through other means, such as scientific or technical journals. This reason has a special importance, for if it is true, the need to correct the other problems just mentioned would be lessened, since the researcher would simply not need patents. Evidence for or against the belief that journals reproduce most of the information contained in patents should, then, be considered before extensive action is taken on the other problems that interfere with the use of patent literature.

Information on the extent of publication of U. S. patented technology appears to be virtually unknown. A literature search uncovered only two studies that disclosed any information on this subject and both of these seem to relate mainly to foreign patents. In an article published by UNESCO, Vcerasnij [5] states, without apparent detailed statistical analysis, that only 5-10% of new technological solutions offered by patents is published in the literature. This view receives confirmation from a detailed study performed by researchers at the School of Librarianship of the Polytechnic of North London which found that only 5.77% of the technology in British patents was reported in the non-patent literature. (See footnote 2.)

Purpose And Scope

The study reported here attempts to quantify the extent to which technology described in U. S. patents has been published in the non-patent literature.

In resolving this question the study examines with particular care publication resources most likely to be available to the researcher and inventor rather than resources such as trade catalogs and in-house journals, since these have only a limited circulation and lack secondary sources to assist the outsider. Four principal reference sources were used: Science Citation Index (SCI); Chemical Abstracts (CA); Electrical and Electronics Abstracts (EEA); and, Engineering Index (EI).

SCI is a broad based reference source, covering all disciplines, which indexed virtually all items from 1500-2000 journals in the period 1967-72. CA abstracts articles, having primarily a chemical focus which, as of 1973, covered almost 13,000 journals. EEA and EI are somewhat smaller indices; EEA abstracts electrical and electronic articles from about 2,000 journals

---

5 R. Vcerasnij, UNESCO, Bull. for Libraries, Vol. 23, No. 5, pp 234-239 (1969)

whereas EI abstracts engineering articles from 1300 journals. While some overlap in coverage obviously exists among these abstracting services, the four secondary sources together were felt to provide sufficient depth and breadth of coverage of the publications generally available to the scientific and technical community. Support for this position can be found in recent studies wherein researchers conclude that 1,000 journals contain over 80% of all scientific articles published[6,7].

The study examines the rate of publication in the non-patent literature of technology patented in the U.S. in two years - 1967 and 1972. 1972 was the most recent year chosen to assure that enough time had elapsed from the grant date of the patent to the point where publication of the patented technology could be identified. The British study indicated, that for publications issuing after the patent grant date, 98% occurred within the first four years following the patent grant date.

A second year, 1967, was chosen to give a five year span between samples to provide a means of determining whether the publication rate of patented technology in the non-patent literature is time dependent.

For each year, a random sample of 220 patent numbers was selected. Five patents from the 1972 sample were subsequently found to have been withdrawn, so 215 patents constituted the sample for that year. The number was chosen as one giving a statistically valid sample population and a sample size that could be investigated within the period of five months available for this project. Assuming a 5% publication rate, a sample size of 220 would give results having an accuracy of $\pm$ 2.4% at a .90 confidence level.

The patents were selected at equal intervals from a list of the year's patent numbers. The interval was the year's total number of patents divided by 220. The 220 patent numbers were chosen by adding multiples of this quotient to the initial patent number selected -- in this case, the first patent of the year. The selection process produces a random sample of a year's patents under the assumption that patents receive their numbers randomly. Even though U.S. patents are issued each week by subject category, past experience has shown that if a sufficiently small interval is used, a random sample will be produced.

To verify the presumed randomness of the sample, the percentages of chemical (C), electrical (E), mechanical (M), U.S. and foreign origins[8] U.S. patents issued in each year were compared to the percentages found in the sample. The variations, shown in the Figure 2-1, did not indicate an important difference between the percentage issued each year and the percentage found in the sample for each of the categories.

---

6 Weinstock M. (1971). Citation Indexes. Encyclopedia of Lib. and Info. Sci. (Vol. 5. pp. 16-40)

7 Price, D.J. de S. (1965). Is Technology Historically Independent of Science? A Study in Statistical Historiography. Technol. Culture Vol. VI. No. 4. pp. 553-568.

8 U.S. patents with foreign resident inventors are considered to be of foreign origin.

Figure 2-1

COMPARISON OF THE PROJECT SAMPLE
TO ALL PATENTS ISSUING IN 1967 AND 1972

| | Project Sample | | All Patents | |
|---|---|---|---|---|
| | % | No. | % | No. |
| 1967 | | | | |
| TOTAL | | 220 | | 65647 |
| DISCIPLINE | | | | |
| Chemical | 23.2% | (51) | 25.3% | (16619) |
| Electrical | 16.4% | (36) | 18.1% | (11867) |
| Mechanical | 60.4% | (133) | 56.6% | (37161) |
| ORIGIN | | | | |
| U.S. | 78.2% | (172) | 78.1% | (51269) |
| For | 21.8% | (48) | 21.9% | (14378) |
| 1972 | | | | |
| TOTAL | | 215 | | 74808 |
| DISCIPLINE | | | | |
| Chemical | 29.8% | (64) | 31.2% | (23360) |
| Electrical | 20.5% | (44) | 18.9% | (14111) |
| Mechanical | 49.7% | (107) | 49.9% | (37337) |
| ORIGIN | | | | |
| U.S. | 67.5% | (145) | 68.9% | (51514) |
| For. | 32.5% | (70) | 31.1% | (23294) |

Methodology

A copy of each patent in the sample was obtained. The specification was carefully examined and all new technology disclosed in the document was identified. For this study, new technology was defined as the technology identified by the inventor(s) as being new. Technology discussed under the introduction or prior art section of the patent specification was excluded. In some cases abstracts of the patents were prepared to aid the investigator in his search for the technology. Then the patents were grouped into the major discipline (Chemical, Electrical and Mechanical) and first searched by inventor's name(s) in the author section of SCI and in one of three secondary reference or abstracting journals depending on the discipline involved - CA for chemical and related technologies, EEA for electrical engineering and electronics, and EI for mechanical engineering. The author search would identify any article by an inventor.

Once a related article was identified it was examined by a reviewer trained in that discipline to determine if the article disclosed the patented technology. Since patent specifications almost always disclose more technology than literature articles, an estimate of the amount of technology disclosed in the article was also made. An article was considered to "substantially" disclose the technology in a patent if 75% or more of the patented technology was reported in the article; if less than 75% was reported it was considered a "partial" disclosure of the technology.

If an article was pertinent, the publication date of the article was also recorded and compared to the patent grant date to ascertain the "age" of the technology disclosed in the patent. Of particular interest is whether disclosure in the non-patent literature occurs prior or subsequent to the publication date of the patent. In the former case, where the article fully disclosed the subject matter of the patent, information discernible from the patent document would be "stale" by the time of publication of the patent. In the latter case, the patent document would be the first and earliest publication of the technology and of greater benefit to information seekers.

Author searches were begun 1 year prior to the filing date of the patent application - which is the statutory "grace" period for filing a patent application on an invention which has been revealed in a publication. A publication prior to this period would be a statutory bar which would have prevented the patent from issuing.

It was realized that the major abstracting journals mentioned above probably do not include every publication authored by one or more inventors in the sample. To estimate the number of these publications that may have been missed, a telephone interview was conducted with at least one inventor in each of 45 U.S. patents of U.S. origin in the 1972 sample. While the secondary reference sources used may not include some publications, it was felt that inventors would be able to identify all relevant articles which they published.

Another limitation of the author search is that it identifies only publications authored by one or more inventors of the examined patents and not publications by others (non-inventors), relating to the patented technology. To estimate the publication rate by non-inventors, a subject search of 54 patents in the sample (24 from 1967, 30 from 1972) was conducted.

The subject searches were begun at the earliest feasible date of the technology, e.g., a laser technology would be searched back to the date of invention of the laser. For the most part, CA, EEA and EI were the reference sources of choice, depending on the particular discipline of the technology. However, the searchers were instructed to use whatever resources were deemed appropriate.

In one sense the subject search gives the most complete results since it should identify publications by both inventors and non-inventors. However, it is also the most demanding in terms of time and professional personnel needed since it requires an intimate knowledge of the technology being searched, extensive knowledge on how a particular subject would be indexed, and a certain amount of ingenuity on the part of the searcher. Because of these requirements, the sample selected for the subject search was necessarily considerably smaller than that used in the author search.

The results were recorded as the percentage of patents disclosed in each search. Where appropriate the percentages were adjusted for the true proportion of chemical, electrical and mechanical patents issuing in the sample years.

Results:

Subject Search

As expected, different publication rates were observed in each of the three searches -- the subject search, author search, and telephone survey. The first of these is felt to be the best indication of the actual publication rate, because it is the only search which measures publications by all authors -- inventors and non-inventors. The overall results of the subject search for 1967 and 1972 combined are given in Figure 2-2.

Of 54 patents in this sample, 38 (70.7 $\pm$ 10.2%) were undisclosed, i.e., not the subject of publication in the non-patent literature covered by the secondary reference sources employed. The remaining 16 patents (29.3% $\pm$ 8.8%) were the subject of at least one publication in the non-patent literature, but of these, only 9 (16.0% $\pm$ 8.2%) were substantially disclosed. 7 patents (13.3% $\pm$ 6.0% of the sample) were only partially disclosed by non-patent publications; these, for the most part, were only minimally disclosed in articles which had no specific reference to the patent and they were only marginally useful for disclosing the patented technology. In some cases a more accurate measure of the patented technology that would not be identified in a search of only the non-patent literature is the undisclosed rate (70.7%) plus the partially disclosed rate (13.3%) or 84.0 $\pm$ 8.3% of the patents in this sample.

---

9 The plus (+) and minus (-) percent indicate the confidence interval.

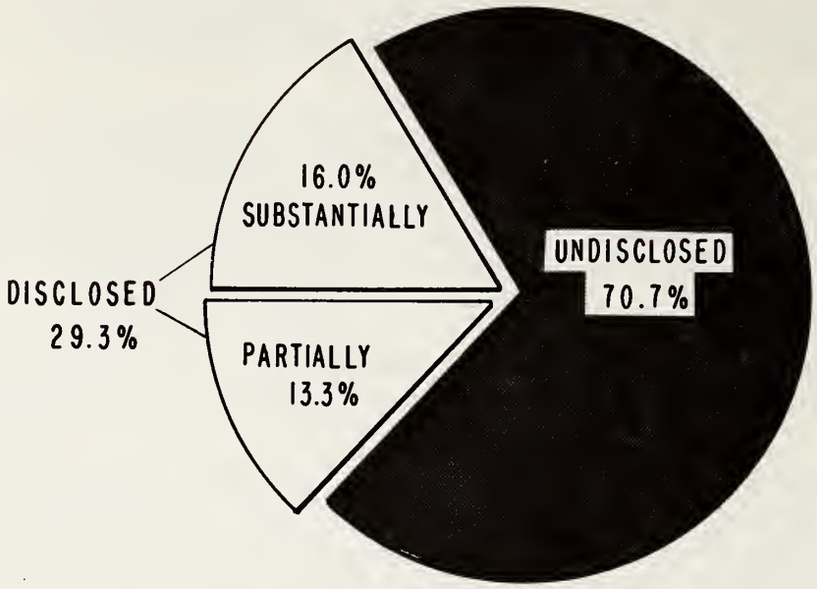



FIG. 2-2: RATE OF DISCLOSURE OF PATENTED TECHNOLOGY-FROM SUBJECT SEARCH OF 1967 AND 1972 PATENTS

The detailed results of the subject search, by year and discipline, are given in Figure 2-3. Two trends were noted: First, the publication rate varied with the discipline within each year. Considering total disclosure for 1967 and 1972 combined, the rate of publication is greatest for chemical, 66.7%. While electrical, 20.0%, appears to be larger than mechanical, 12.5%, the difference is not statistically significant. The second trend noted was that the rate appears to have increased (25.0% to 33.3%) in the period 1967 to 1972. However, the difference (8.3%) falls within the "confidence interval" (i.e., margin of error) for the sample size used. Therefore, the difference can not be regarded as statistically significant.

Author Search

As previously indicated publications of patented technology are of two types - those initiated by inventors of the technology, and those by other authors (non-inventors). The author search was undertaken to measure the extent and time to publication by inventors of patented technology in the non-patented literature. Also, because name searching is much simpler than subject searching (no searching terms or coding of the technology is required), it was possible to employ much larger samples in this search than were employed in the subject search. This gave an improvement in the confidence levels of the results and enabled valid comparisons to be made between all disciplines, U.S. and foreign categories, and years. The results of this search are given in Figure 2-4.

FIGURE 2-3

SUBJECT SEARCH RESULTS

| | 1967 Disclosure Rate | | | 1972 Disclosure Rate | | | 1967 + 1972 Disclosure Rate | | |
|---|---|---|---|---|---|---|---|---|---|
| | Substantial | Partial | Total | Substantial | Partial | Total | Substantial | Partial | Total |
| TOTAL | | | | | | | | | |
| Sample Size | | | 24 | | | 30 | | | 54 |
| Patents Disclosed | 3 | 3 | 6 | 6 | 4 | 10 | 9 | 7 | 16 |
| Percent | 12.5% | 12.5% | 25.0% | 20.0% | 13.3% | 33.3% | 16.0% | 13.3% | 29.3% * |
| Confidence Interval | 4.7-26.4% | 4.7-26.4% | 10.5-42.3% | 8.4-33.6% | 5.9-26.6% | 18.3-49.2% | ± 8.2% | ± 6.0% | ± 8.8% |
| CHEMICAL | | | | | | | | | |
| Sample Size | | | 6 | | | 9 | | | 15 |
| Patents Disclosed | 0 | 3 | 3 | 3 | 4 | 7 | 3 | 7 | 10 |
| Percent | 0% | 50.0% | 50.0% | 33.3% | 44.4% | 77.8% | 20.0% | 46.7% | 66.7% |
| Confidence Interval | 0 -34.5% | 20.1-79.9% | 20.1-79.9% | 12.9-61.0% | 21.0-76.8% | 48.5-93.9% | 7.6-40.0% | 24.7-67.5% | 40.0-84.6% |
| ELECTRICAL | | | | | | | | | |
| Sample Size | | | 5 | | | 10 | | | 15 |
| Patents Disclosed | 2 | 0 | 2 | 1 | 0 | 1 | 3 | 0 | 3 |
| Percent | 40.0% | 0% | 40.0% | 10.0% | 0% | 10.0% | 20.0% | 0% | 20.0% |
| Confidence Interval | 11.2-75.3% | 0 -37.9% | 11.2-75.3% | 1 -35.2% | 0 -22.2% | 1 -22.2% | 7.6-40.0% | 0 -15.4% | 7.6-40.0% |
| MECHANICAL | | | | | | | | | |
| Sample Size | | | 13 | | | 11 | | | 24 |
| Patents Disclosed | 1 | 0 | 1 | 2 | 0 | 2 | 3 | 0 | 3 |
| Percent | 7.7% | 0% | 7.7% | 18.2% | 0% | 18.2% | 12.5% | 0% | 12.5% |
| Confidence Interval | .8-27.6% | 0 -17.3% | .8-27.6% | 4.9-42.3% | 0 -19.7% | 4.9-42.3% | 4.7-26.4% | 0 -10.5% | 4.7-26.4% |
| FOREIGN | | | | | | | | | |
| Sample Size | | | 5 | | | 10 | | | 15 |
| Patents Disclosed | 1 | 1 | 2 | 2 | 0 | 2 | 3 | 1 | 4 |
| Percent | 20.0% | 20.0% | 40.0% | 20.0% | 0.0% | 20.0% | 20.0% | 6.7% | 26.7% |
| Confidence Interval | 2.1-62.1% | 2.1-62.1% | 11.2-75.3% | 5.5-50.0% | 2.0-22.2% | 5.5-50.0% | 7.6-40.0% | .7-24.7% | 12.4-50.0% |
| U.S. | | | | | | | | | |
| Sample Size | | | 19 | | | 20 | | | 39 |
| Patents Disclosed | 2 | 2 | 4 | 4 | 4 | 8 | 6 | 6 | 12 |
| Percent | 10.5% | 10.5% | 21.1% | 20.0% | 20.0% | 40.0% | 15.4% | 15.4% | 30.8% |
| Confidence Interval | 2.8-26.5% | 2.8-26.5% | 9.5-38.7% | 9.0-36.7% | 9.0-36.7% | 22.1-63.3% | ± 9.5% | ± 9.5% | ± 12.2% |

* Adjusted for the true proportion of chemical, electrical and mechanical patents issuing in the sample year

FIGURE 2-4

AUTHOR SEARCH RESULTS

| | 1967 Disclosure Rate | | | 1972 Disclosure Rate | | | 1967 + 1972 Disclosure Rate | | |
|---|---|---|---|---|---|---|---|---|---|
| | Substantial | Partial | Total | Substantial | Partial | Total | Substantial | Partial | Total |
| TOTAL | | | | | | | | | |
| Sample Size | | | 220 | | | 215 | | | 435 |
| Patents Disclosed | 8 | 6 | 14 | 17 | 13 | 30 | 25 | 19 | 44 |
| Percent | 3.9%* | 2.8%* | 6.8%* | 8.1%* | 6.3%* | 14.4%* | 5.9%* | 4.6%* | 10.5%* |
| Confidence Interval | ± 2.2% | ± 1.8% | ± 2.8% | ± 3.1% | ± 2.6% | ± 3.8% | ± 1.9% | ± 1.6% | ± 2.4% |
| CHEMICAL | | | | | | | | | |
| Sample Size | | | 51 | | | 64 | | | 115 |
| Patents Disclosed | 4 | 4 | 8 | 9 | 11 | 20 | 13 | 15 | 28 |
| Percent | 7.8% | 7.8% | 15.7% | 14.1% | 17.2% | 31.3% | 11.3% | 13.0% | 24.3% |
| Confidence Interval | ± 6.2% | ± 6.2% | ± 8.3% | ± 7.1% | ± 7.8% | ± 9.3% | ± 4.8% | ± 5.2% | ± 6.6% |
| ELECTRICAL | | | | | | | | | |
| Sample Size | | | 36 | | | 44 | | | 80 |
| Patents Disclosed | 3 | 0 | 3 | 0 | 1 | 1 | 3 | 1 | 4 |
| Percent | 8.3% | - | 8.3% | - | 2.3% | 2.3% | 3.8% | 1.3% | 5.0% |
| Confidence Interval | ± 7.6% | - | ± 7.6% | - | ± 3.7% | ± 3.7% | ± 3.5% | ± 2.0% | ± 4.0% |
| MECHANICAL | | | | | | | | | |
| Sample Size | | | 133 | | | 107 | | | 240 |
| Patents Disclosed | 1 | 2 | 3 | 8 | 1 | 9 | 9 | 3 | 12 |
| Percent | .75% | 1.5% | 2.3% | 7.5% | .9% | 8.4% | 3.8% | 1.3% | 5.0% |
| Confidence Interval | ± 1.2% | ± 1.7% | ± 2.3% | ± 4.2% | ± 1.5% | ± 4.4% | ± 2.0% | ± 1.2% | ± 2.3% |
| FOREIGN | | | | | | | | | |
| Sample Size | | | 48 | | | 70 | | | 118 |
| Patents Disclosed | 2 | 0 | 2 | 7 | 4 | 11 | 9 | 4 | 13 |
| Percent | 4.2% | 0% | 4.2% | 10.0% | 5.7% | 15.7% | 7.6% | 3.4% | 11.0% |
| Confidence Interval | ± 4.7% | - | ± 4.7% | ± 5.9% | ± 4.6% | ± 7.2% | ± 4.0% | ± 2.7% | ± 4.7% |
| U.S. | | | | | | | | | |
| Sample Size | | | 172 | | | 145 | | | 317 |
| Patents Disclosed | 6 | 6 | 12 | 10 | 9 | 19 | 16 | 15 | 31 |
| Percent | 3.5% | 3.5% | 7.0% | 6.9% | 6.2% | 13.1% | 5.0% | 4.7% | 9.8% |
| Confidence Interval | ± 2.3% | ± 2.3% | ± 3.2% | ± 3.5% | ± 3.3% | ± 4.6% | ± 2.0% | ± 2.0% | ± 2.7% |

* Adjusted for the true proportion of chemical, electrical and mechanical patents issuing in the sample year.

Of 435 patents searched (220 from 1967 and 215 from 1972), only 44 or 10.5 ± 2.4% were the subject of publication in the non-patent literature. For both years, more chemical patents were disclosed than electrical patents, and electrical patents were disclosed at about the same rate as mechanical patents. The retrieval rates for 1967 and 1972 combined were: Chemical 24.3% ± 6.6%; Electrical 5.0% ± 4.0%; and Mechanical 5.0% ± 2.3%. The origin of the patents appears to have little effect on publication rate. Patents of U.S. origin were disclosed at about the same rate as patents of foreign origin; 9.8% ± 4.7% for U.S. vs. 11.1% ± 2.7% for foreign.

Between years, an increase in publication rate was observed for 1972 as compared to 1967 (14.4% ± 3.8% vs. 8.1% ± 3.1%). This indicates that inventors of 1972 patents are more likely to have published on their inventions than inventors of 1967 patented technology.

Telephone Survey

The telephone survey was undertaken to check the effectiveness of the secondary reference sources in picking up all pertinent references, the assumption being that inventors would be able to identify any articles that they may have published. Only 1972 patents were used since the needed bibliographic information for those was more current.

The results of this investigation are given in Figure 2-5. Of 45 patents in this sample, 20.0%± 10.1% were identified as being the subject of publication in the non-patent literature. This value does not differ significantly from the 14.4%±3.8% found for 1972 in the more extensive author searches -- indicating that the secondary reference sources, SCI, CA, EEA, and EI adequately cover publications of these patents by inventors in that year. Of the references identified in the telephone survey, only 1 was not found in the author search. This reference was identified by journal name and year only, and a review of this journal's publications for the complete year, and adjacent years, failed to turn up this reference.

None of the inventors contacted were able to identify any articles written by others; although, the subject search turned up additional references by non-inventors on patents common to the telephone search. It appears from this result that inventors are able to provide adequate information about articles that they have authored; but are not necessarily able to provide information about publications by others.

FIGURE 2-5

TELEPHONE SURVEY RESULTS

1972

Disclosure Rate

| | Substantial | Partial | Total |
|---|---|---|---|
| TOTAL | | | |
| Sample Size | | | 45 |
| Number of Hits | 6 | 2 | 8 |
| Percent | 13.3% | 4.4% | 20.0% |
| Confidence Interval | ± 8.3% | ± 5.1% | ± 10.1% |
| CHEMICAL | | | |
| Sample Size | | | 15 |
| Number of Hits | 4 | 1 | 5 |
| Percent | 26.7% | 6.7% | 33.3% |
| Confidence Interval | 12.2-50.0% | .7-24.7% | 15.4-60.0% |
| ELECTRICAL | | | |
| Sample Size | | | 15 |
| Number of Hits | 0 | 0 | 0 |
| Percent | 0% | 0% | 0% |
| Confidence Interval | 0-15.4% | 0-15.4% | 0-15.4% |
| MECHANICAL | | | |
| Sample Size | | | 15 |
| Number of Hits | 2 | 1 | 3 |
| Percent | 13.3% | 6.7% | 20.0% |
| Confidence Interval | 3.6-32.6% | .7-24.7% | 7.6-40.0% |

Inventor vs. Non-Inventor Initiated Publication in the Non-Patent Literature

The search results for patents common to both the author and subject studies were analyzed to determine the extent of publication in the non-patent literature by inventors vs. non-inventors. The sample for this study was the 54 patents investigated in the subject search, each of which was also investigated in the author search. These results are given by year in Figure 2-6. They show that the majority of non-patent publications on 1967 patented technology were authored by non-inventors. In 1972, a reversal of this trend was noted, 66.7% of all non-patent publications being authored by the inventor of the technology.

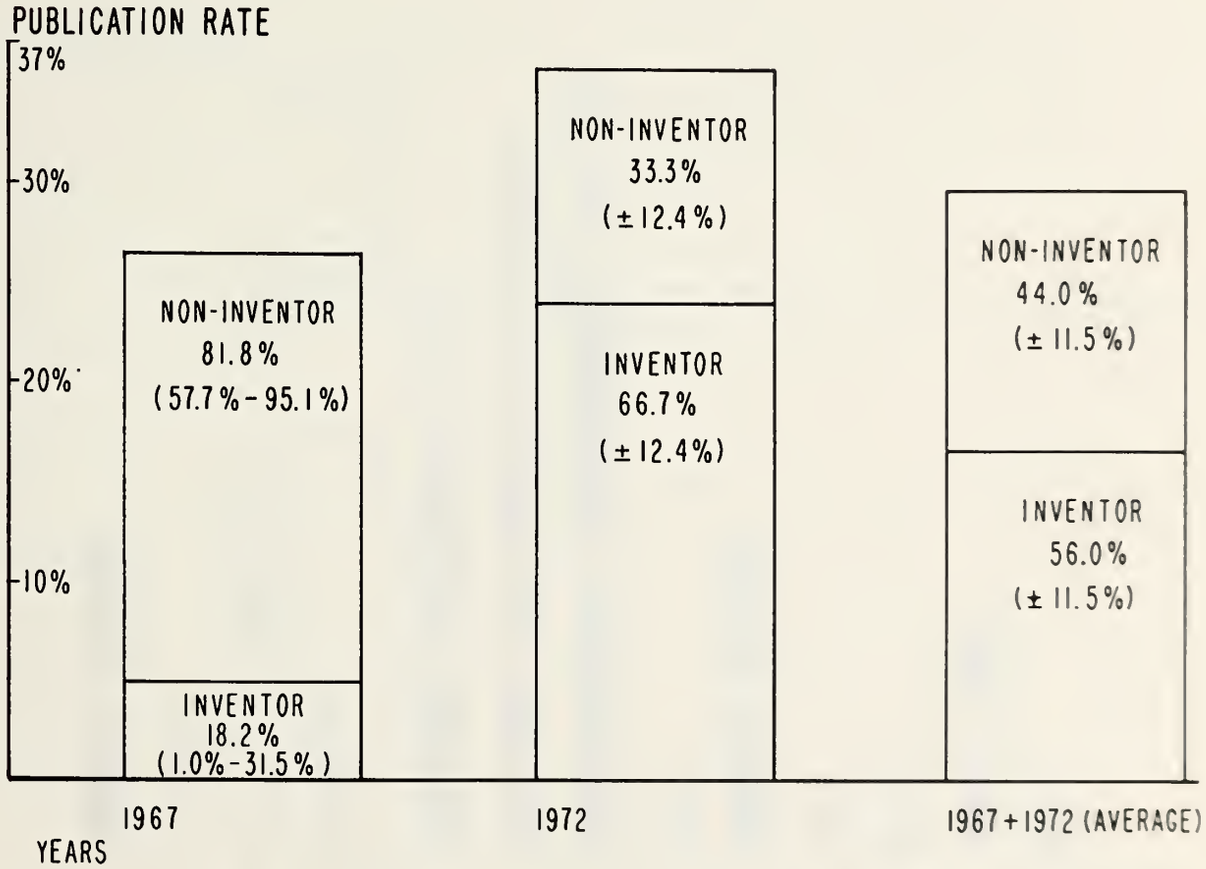



FIG. 2-6: A COMPARISON OF INVENTOR AND NON-INVENTOR AUTHORSHIP OF PUBLICATIONS TO PATENTED TECHNOLOGY

Time Interval to Disclosure of Patented Technology

For each patent disclosed in one or more non-patent publications, the earliest published article located was analyzed to determine the time interval from its publication date to the grant date of the patent. The results of this analysis are tabulated, by discipline, in Figure 2-7. The data demonstrate that for patents disclosed in the non-patent literature, publication, for the most part, occurred prior to the issuance of the patents and that chemical patents are more frequently and earlier disclosed than either electrical or mechanical patents. Disclosure prior to the patent grant date mostly occurs in the three year period preceeding this date. For non-patent publications subsequent to the granting of the patent, most occur within the first three years following the patent grant. Also, publications subsequent to the patent grant were more prevalent in the chemical and mechanical disciplines.

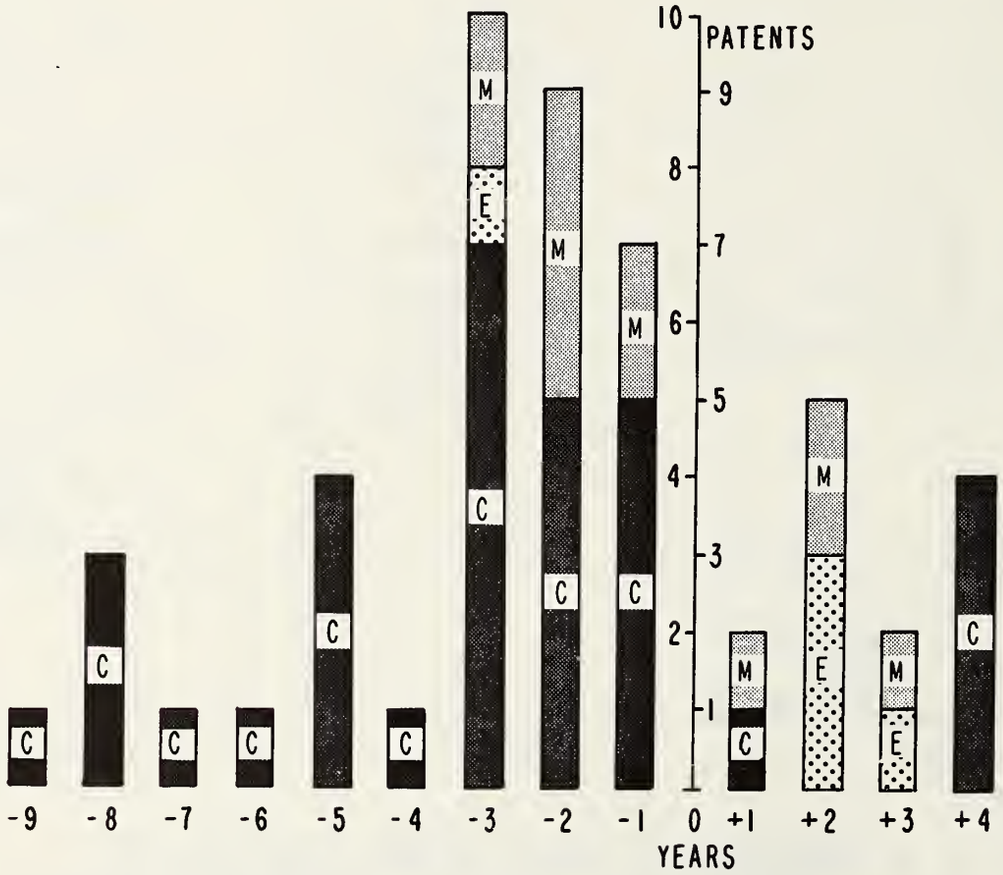



FIG. 2-7: RELATIVE TIME FROM THE PATENT GRANT DATE TO PUBLICATION IN THE NON-PATENT LITERATURE

## Multiple Disclosure of Patented Technology

In Figure 2-8, the number of patents having multiple disclosure in the non-patent literature is given by year and discipline. Again the most pronounced results were noted for chemical patents; more had multiple publication than patents of other disciplines. One chemical patent had twenty references which to some degree disclosed the patented technology. Multiple references in the electrical and mechanical areas were far less prevalent both with regard to the number of patents having multiple hits and the number of multiple hits per patent.

FIGURE 2-8

THE NUMBER OF PATENTS HAVING MULTIPLE DISCLOSURES IN THE NON-PATENT LITERATURE BY YEAR AND DISCIPLINE

| NO. OF IDENTICAL OR SIMILAR PUBLICATIONS | 2 | 3 | 4 | 5 | 6 | 7 | 8 | . . . . . | 12 | . . . . . | 20 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | -NUMBER OF PATENTS- | | | | | | | | | | | |
| ALL PATENTS | | | | | | | | | | | | |
| 1967 | 6 | 4 | 1 | | | | | | | | | |
| 1972 | 4 | 2 | 1 | 2 | 3 | 1 | 1 | | 1 | | 1 | |
| TOTAL | 10 | 6 | 2 | 2 | 3 | 1 | 1 | | 1 | | 1 | TOTAL 27 |
| CHEMICAL | | | | | | | | | | | | |
| 1967 | 5 | 3 | 1 | | | | | | | | | |
| 1972 | 2 | | 1 | | 2 | 1 | 1 | | 1 | | 1 | |
| TOTAL | 7 | 3 | 2 | | 2 | 1 | 1 | | 1 | | 1 | TOTAL 18 |
| ELECTRICAL | | | | | | | | | | | | |
| 1967 | 1 | 1 | | | | | | | | | | |
| 1972 | | | | | | | | | | | | |
| TOTAL | 1 | 1 | | | | | | | | | | TOTAL 2 |
| MECHANICAL | | | | | | | | | | | | |
| 1967 | | | | | | | | | | | | |
| 1972 | 2 | 2 | | 2 | 1 | | | | | | | |
| TOTAL | 2 | 2 | | 2 | 1 | | | | | | | TOTAL 7 |

## CONCLUSION

The results of this study show that about 8 out of 10 U.S. patents contain technology not disclosed in the non-patent literature. These results demonstrate that patents are an essential source of technology which cannot be ignored by scientists, technologists, and information specialists, without encountering a serious risk of missing relevant technology.

## II THE PATENT FILE AS A TECHNOLOGICAL RESOURCE

### Background

The voluminous collection of technical literature contained within the U.S. Patent and Trademark Office - numbering approximately 22 million documents - is known as the patent file. In this file are about 11.5 million U.S. patent documents, some 9.5 million foreign patent documents and approximately 1 million pieces of non-patent literature, classified into more than 95,000 subdivisions of technology, called subclasses. Each year the file grows with the addition of about 500,000 new documents.

Within this file can be found the disclosure of almost all major technological advances that have occurred both here and abroad during the 187 years since the first U.S. patent was granted. The patent file, therefore, represents a compendium of the history, development and current status of technology. In a sense, the patent file also is an irreplaceable national resource, because much of the technical information it contains is not duplicated elsewhere. As was seen in Part I of this Section, 84% or about 8 of every 10 patents, contain technical information not reported elsewhere in the non-patent literature. More than 7 out of every 10 patents are not the subject of any publication in the non-patent literature.

In 1971, the Assistant Secretary of Commerce for Science and Technology, recognizing that the potential of the patent file as a technological resource was not being fully utilized, asked the Office of Technology Assessment and Forecast (OTAF) within the Patent and Trademark Office to undertake, in cooperation with the private sector, a test of the usefulness of the patent file as a source of technical information.

### Methodology

The following test was proposed: A private organization's cooperation would be secured to conduct a joint search project with OTAF. First the organization would select a fairly limited technological problem(s) in which they had interest. Together OTAF and the private organization would determine the technology pertinent to the problem(s). Then the organization would proceed to develop, in its usual manner, the available technical information relating to the problem. Concurrently, OTAF would identify, by searching the patent file, the patents in the pertinent technology. A third party would then make a comparison to ascertain whether the results of the patent file search revealed information pertinent to the problem that had not been developed by the private organization.

The American Chemical Society (ACS) agreed to act as both the intermediary in securing the cooperation of a private organization and the "third party" to evaluate the results. In its first role, ACS secured the efforts of the Universal Oil Products Company (UOP) of Des Plaines, Illinois.[10]

---

10 Appreciation is extended to UOP, in particular Leonore Rogalski, UOP Research Library supervisor; and to ACS for their interest and cooperation which made this study possible.

UOP suggested two technological areas of interest to them - Non-lead Antiknock Agents and Nitrogen Fixation. Search statements for each of these areas, acceptable to both UOP and OTAF, were prepared and searched. The search statements and sources used in the searches are as follows:

Non-lead Antiknock Additives for Gasoline

Search Statement

> This study is aimed at antiknock compounds other than those containing lead for gasolines for automotive use. Patents and articles that describe the use of an additive in conjunction with lead compounds or leaded fuels are to be excluded. Variations of the hydrocarbon composition of gasolines to improve octane numbers through special refining processes or the blending of hydrocarbon stocks are also to be excluded. The search will cover material from 1945 to date.
>
> Comments: For the UOP and OTAF searches, preignition and surface ignition additives as well as color stabilizers for antiknock additives were not considered relevant. However, alcohols, amines and other non-hydrocarbons used in gasoline blends were considered somewhat differently in the two searches. UOP considered all of these to be antiknock agents, whereas, OTAF considered these pertinent only if there was a disclosure of antiknock utility or the additive was from a class of compounds known to have antiknock utility.

Sources Used

UOP

1) Chemical Abstracts, 1945-Jan. 1975, as follows:
   (a) CHEMCON data base, 1972-Jan. 1975.
   (b) General Subject Indexes for Vols. 76-80, 1972-June 1974, under the subjects: Gasoline additives and Octane number.
   (c) Eighth Collective Subject Index for Vols. 66-75, 1967-1971, under the subjects: Fuels, Gasoline additives, and Octane number or value.
   (d) Seventh, Sixth and Fifth Collective Subject Indexes for Vols. 41-65, 1947-1966, under the subjects: Detonation, Fuels, Gasoline, and Octane number or value.

---

11 The search statements and UOP sources used were taken verbatim from UOP's search report.

(e) Fourth Decennial Subject Index, retrieving only references for Vols. 39-40, 1945-1946, under the same subjects as listed in (d).

2) American Petroleum Institute literature and patent data bases, 1964-Jan. 1975.

Search strategy was:

All antiknock agent # and motor gasoline and not lead.

3) Information for Industry U.S. Chemical Patents data base, 1950-Sept. 1974.

Search strategy was:

Antiknock compounds but not (lead compounds and salts/sto/ or organic lead compounds and salts/sto or lead, tetraethyl- or lead, tetramethyl- or lead organic or patent classes: M 44-69, X44-69, and M208).

OTAF

Examiner's search files: Class 44, subclasses 51-68, 70-80; Class 252, subclasses 373, 386; and Class 260, subclass 429CY.

Nitrogen Fixation

Search Statement

Material in this search will cover methods of nitrogen fixation other than Haber, arc or biological processes. Other exclusions will be nitrogen fixation by the use of radiation or shock waves. The search will cover conversion of nitrogen to ammonia, hydrazine, and oxides and oxy acids of nitrogen. The methods will involve reaction conditions close to standard temperature and pressure. The search will cover 1950 to date.

Sources Used

UOP

1) Chemical Abstracts, 1950-Jan. 1975 as follows:
(a) CHEMCON data base 1972-Jan. 1975.

(b) General Subject Indexes for Vols. 76-80, 1972-June 1975 under the subject heading: Nitrogen fixation, synthetic.

(c) Eighth Collective Subject Index for Vols. 66-75, 1967-1971 under the subjects: Ammonia, manufacture of; Hydrazine, manufacture of; Nitrification; Nitrogen fixation, synthetic and Nitrogen oxides.

(d) Sixth and Seventh Collective Subject Indexes Vols. 51-65, 1957-1966, under the subjects: Ammonia, manufacture of; Hydrazine, manufacture of; Nitrification, Nitrogen fixation, and Nitrogen oxides.

(e) Fifth Decennial Subject Index, retrieving only references from 1950 on under the same subjects as (d) above.

2) American Petroleum Institute literature and patent data bases, 1964-Jan. 1975.

Search strategy was the term: Nitrogen fixation.

3) Information for Industry.

Search strategy was:

(a) Fixation/Nitrogen/ or Nitrogen, Nitrobacteria/sto/or fixing, fixation, fixative, repair /sto/ but not (Anaerobic processes or Fermentation or Enzymes/hydrolases/ or Enzymes/ isomerases/ or Enzymes/lyases/ or Enzymes/ other /or Enzymes/ oxidoreductases/ or Enzymes/sto/ or Enzymes/synthetases/ or Enzymes/transferases/ or Bacteria, bacteriology/sto/ or Bacteria/other/ or Bacteria cyclooxidans or Microorganisms or High temperature) and (Low termperature or Low pressure or 1°C to 50°C. 33°F to 122 F, Room temperature/sto/ or Low/sto/.)

(b) Nitrogen, nitrobacteria/sto/ or Nitrogen and (M423 subclasses 354, 359, 360, 361, 362, 363, 364, 371, 374, 380, 381 or 382) but not (high temperature or 101°C - 500°C temperature range categories).

OTAF:

Examiner's Patent File - Class 55, subclasses 68, 70, 74-79, 387-390; Class 71, subclasses 54-60; Class 204, subclasses 60-63, 101, 102, 177; Class 252, subclasses 431R-L, 441,442; Class 260, subclasses 429R, 429CY, 429.3-430, 438.1. 438.5R, 439R, 439CY, 440, 446, 447; and Class 423, subclasses 210, 210.5, 235, 239, 351, 352, 359-363, 385, 390, 395, 400, 402, 406, 407, 413, 644, 645.

RESULTS:

The result of the searches are shown in Figure 2-9. In both searches OTAF found a significant number of U.S. patents not identified by UOP -79 in the antiknock study and 10 in the Nitrogen Fixation search. UOP also found a significant number of references not found by OTAF. Some of these, notably the literature references found in both searches, reflect the differences in the data bases used. UOP utilized commercial data bases that extensively cover the non-patent literature. OTAF, on the other hand, utilized the examiners' patent search files which, while containing all U.S. patents in a given technological area (e.g., subclass), have less comprehensive coverage of foreign patents in the area and, generally, few if any literature references[12]. However, UOP also uncovered a significant number of U.S. patents (69) in the antiknock study not identified by OTAF. Most of these were pertinent to the subject but were classified in subclasses whose definition did not appear to OTAF to be germane to the search statement.

On the basis of the numbers of patents found by UOP and OTAF, the ACS concluded that both organizations found pertinent references not found by the other. The results appear to support a well-known axiom in the information retrieval business, namely that no one source of information is 100% effective for complete retrieval. An adequate search becomes a question of how much time and energy one can afford to spend to get reasonable and workable results.

If the identification of all relevant art is the goal of an information search, a certain redundancy must be built into the search scheme. If complete patent information is sought, available commercial data bases can be helpful when used in conjunction with the patent files to uncover all relevant disclosures.

---

12 In examining patent applications, the examiners' search resources are not limited to the patent file. The Patent and Trademark Office maintains an extensive Scientific Library which in addition to the usual literature files, provides access to many on-line commercial scientific and technological data bases.

Figure 2-9

UOP-OTAF SEARCH RESULTS

| | Non-lead Antiknock Agents | Nitrogen Fixation |
|---|---|---|
| I. U.S. Patents | | |
| a. Mutual choice | 209 | 6 |
| b. OTAF only | 79 | 10 |
| c. UOP only | 69* | 0 |
| II. Foreign Patents | | |
| a. Mutual choices | 9 | 0 |
| b. OTAF only | 100** | 0 |
| c. UOP only | 59 | 0 |
| III. Literature | | |
| a. Mutual choice | 1 | 0 |
| b. OTAF only | 1 | 0 |
| c. UOP only | 143 | 72 |

As to the usefulness of the patent file as a source of technical information, the ACS committee involved in the study recommended to ACS the following resolution:

> "Following an exhaustive parallel search by the Patent and Trademark Office, and UOP, Inc. on specific technology, the ACS Committee on Patent Matters and Related Legislation has found that industry apparently does not make adequate use of the Patent and Trademark Office files as an information source. Therefore, the American Chemical Society urges greater availability, in usable form, of Patent and Trademark Office records in other geographical areas for more convenient access to this national resource."

---

* An examination of these patents by OTAF indicated that 23 were duplicates (e.g., divisional patents) or substantial equivalents (e.g., continuation-in-part patents) of patents found by OTAF in 1a and 1b.

** An examination of these foreign patent documents by UOP indicated that 55 were equivalent patents (substantial duplicates of 1 or more other foreign patents found)

# GEOPHYSICAL EXPLORATION FOR HYDROCARBONS (OIL, GAS AND COAL)

In this section, as part of a continuing effort by the Office of Technology Assessment and Forecast (OTAF) to demonstrate uses of patent information, patent activity in geophysical exploration for hydrocarbons and in components of this area is examined. This examination makes use of foreign and corporate patent information and continues a report format first presented in OTAF's Seventh Report*.

## Background

The geophysical exploration area was selected for a number of reasons. First, it is an area of wide spread interest and impact. Over $1 Billion was spent in worldwide geophysical hydrocarbon exploration in 1976 alone**; reflecting the dependency of most nations on oil and gas (the demand for which is sharply increasing as the supply is decreasing) to supply the major part of their energy needs. Second, it is still basically a U.S. technology although foreign activity in this area has been increasing. Thus, the problem of foreign technological developments which are not patented in the U.S. is minimized.

It should be emphasized that while geophysical exploration technologies were chosen for patent analysis, the same type of study could be undertaken for virtually any technological area.

Geophysical exploration, broadly, can be defined as the analysis of the earth's structure and composition using physical measurements taken at, or near, the area to be studied. Generally, the area to be studied is hidden from direct view and lies under thousands of feet of soil and rock. Such exploration is used not only in geological studies but also in prospecting for valuable natural resources, including hydrocarbons (oil, gas, coal), minerals and water.

This report studies geophysical exploration for hydrocarbons, a relatively new area of technology, that is only about 50 years old. Since its inception, methods and apparatus used in hydrocarbon exploration have been continually improved or specially modified in order to permit optimum implementation for differing exploration environments, e.g. Arctic tundra, offshore areas, deserts, forests, etc.

---

* See Seventh Report of the Office of Technology Assessment and Forecast, March 1977, page 96, "Computer Memory Components"

** Geophysics, Special Report, Vol. 42, No. 5, pp. 1070-1084

There are four principal methods of geophysical exploration for hydrocarbons: seismic; electrical-magnetic; nuclear; and gravitational. The seismic method is primarily used to determine underground geologic structures which are indicative of adjacent hydrocarbon deposits. Electrical-magnetic and gravitational prospecting methods are primarily used in initial reconnaissance surveys where little is known of the geology and where it is desired to ascertain whether a sufficient thickness of sediments of potential interest is present. Nuclear geophysical prospecting is largely confined to determining, in boreholes, the composition of the subsurface strata.

Procedure

The first step in the patent analysis was to define the area of geophysical exploration in terms of subclasses, the smallest units of the U.S. Patent Classification system. Once this was accomplished, patents in these subclasses could be easily identified and the patent activity analyzed through the use of OTAF's computerized data base.

Relevant classifications were identified through the use of the Patent Classification Manual and in consultation with the patent examiners working in the areas. Altogether, 115 subclasses were found pertinent. An examination of these, as a group, provided useful patent information about the broad area of geophysical exploration. Also, because the Classification System is heirarchical in nature, consideration of single subclasses permitted patent analysis of components of geophysical exploration methods and systems. By further subdividing a subclass into its components by means of a patent-by-patent analysis, patent information about very specific aspects of the technology were obtained.

The heirarchical nature of the Classification System was used to study geophysical exploration on four different levels. They are identified in Table 3-1.

Table 3-1: GEOPHYSICAL EXPLORATION FOR HYDROCARBONS-METHODS AND SYSTEMS

| | |
|---|---|
| Level 1 | Geophysical Exploration (All Methods & Systems) |
| Level 2<br>Components of Geophysical Exploration For Hydrocarbons | . Seismic Prospecting<br>. Electrical-Magnetic Prospecting<br>. Nuclear Geophysical Prospecting<br>. Gravitational Field Measurement |
| Level 3<br>Components of Seismic Prospecting | .. Offshore Seismic Prospecting<br>.. Seismic Signal Processing<br>.. Seismic Recorders and Displays<br>.. Borehole Logging<br>.. Seismic Wave Sources |

| | |
|---|---|
| Level 4 | ...Seismic Vibrators |
| | ...Air Guns |
| Components of Seismic Sources | ...Solid Explosives |
| | ...Implosive Seismic Wave Generators |
| | ...Gas Exploders |
| | ...Miscellaneous Land Seismic Wave Generators |
| | ...Miscellaneous Marine Seismic Wave Generators |

Each level is made up of the following subclasses and/or patents:

Level 1 - Considers all patents in the 115 subclasses found pertinent.

Level 2 - Divides the 115 subclasses of Level 1 into 4 main groups; the 4 major methods of geophysical exploration. Patent activity in these component areas was identified by considering single subclasses, small groups of subclasses and/or selected patents from subclasses not pertinent in their entirety.

Level 3 - Identifies some of the components of seismic prospecting from Level 2. Patent activity at this level was obtained by considering selected patents from subclasses not pertinent in their entirety and single subclasses directed to areas of interest.

Level 4 - Identifies the components of seismic wave sources from level 3. Patent activity at this level was obtained by considering selected patents from subclasses directed to the area of interest.

After pertinent patents in each area were identified, standard OTAF country/company table reports* were generated for each area and the following patent information was extracted and used as described below:

Patent Activity Data-

January 1967-December 1976 patent activity by year was tabulated both by patent grant date and by the application filing date of these patents.

Patents distributed by application filing date are referred to as patented applications in this study. For the most part, the profiles which follow utilize this patented application date data because the application filing date of a patent is a more accurate reflection of when the technology was developed.

---

* Excerpts from a example of this type of report are in Appendix C.

Distributing 1967-1976 patents on an application date basis provides essentially complete data on those applications, which ultimately became patents, filed each year from 1965 through 1974. This is the case because there is a delay between the filing of a patent application and its subsequent issuance as a patent. The length of this delay (i.e., the "pendency" of an application) is determined by many factors, including Patent and Trademark Office workload, budget and man-power levels, patent printing schedules, etc. Present average pendency is about 19 months; but in 1967 it was over 2 years. Thus, most applications filed in 1965 did not issue as patents until 1967 or later.

In the review of Level 1, the broadest level considered, patent activity by year, is expressed in terms of the actual number of patented applications filed in the area from 1965-1974, and in terms of the percentage those applications were of the total patented applications filed in the Patent and Trademark Office in all technologies, from 1965-1974.

Assignment Data-

Most patents at the time of issue are assigned to corporations or other organizations. These assignments are printed on the patent document, and, since 1969, have been captured on a computerized data base. In the interim about 50,000 different organizations have been recorded as assignees for roughly half a million patents. Such information is of obvious interest in determining who owns what in a given technology.

For this report corporate owned patents in the technology, issuing between January 1969 and December 1976, were extracted and tabulated by assignee and application filing date of these patents. In the most recent three year period (1974-76), 81.9% of all geophysical exploration patents granted were assigned at the time of issue to a U.S. or foreign organization (mostly corporations).

Foreign Activity Data-

For patents issuing in the area from 1967 through 1976, the country of origin (if other than U.S.) as indicated by the residence of the first inventor was recorded. Data were tabulated by year of application filing of these patents and are reported as a percentage ("percent foreign") of the total patented applications filed in the area in each year. This information is useful in determining the position of the United States vis-a-vis foreign countries in this technology.

<u>Content of This Section</u>

The study is provided in two Parts:

Part 1 - Patent Analysis

Part 2 - Profiles of Levels 2 through 4 of Geophysical Exploration Technologies

Part 1 begins with an analysis of the foreign activity in the area. For each technology examined, the degree of foreign activity is expressed graphically as the three year average percent of all patented applications filed in a given area over two time periods, 1965-67 and 1972-1974. In addition, the distribution of the foreign share of the technology among selected countries is shown.

Next, for the broad geophysical exploration area and for the component technologies investigated, overall patent activity is graphically presented and analyzed. Following this is an examination of the specific ownership in the several technological levels and areas investigated in this report.

Part 1 concludes with a general analysis section in which seismic prospecting patent activity is compared to actual field usage of seismic prospecting techniques, and the patent activity for the various seismic wave sources is analyzed for developmental trends.

Part 2 consists of a series of reviews of the patenting in selected component areas of geophysical exploration. These reviews take two forms; detailed reports prepared by the patent examiner responsible for the area under consideration and two page "mini-reports" which present statistical treatments of an area's patent activity and includes brief abstracts of recent patents in the area.

## PART I. PATENT ACTIVITY ANALYSIS

### A. FOREIGN PATENT ACTIVITY

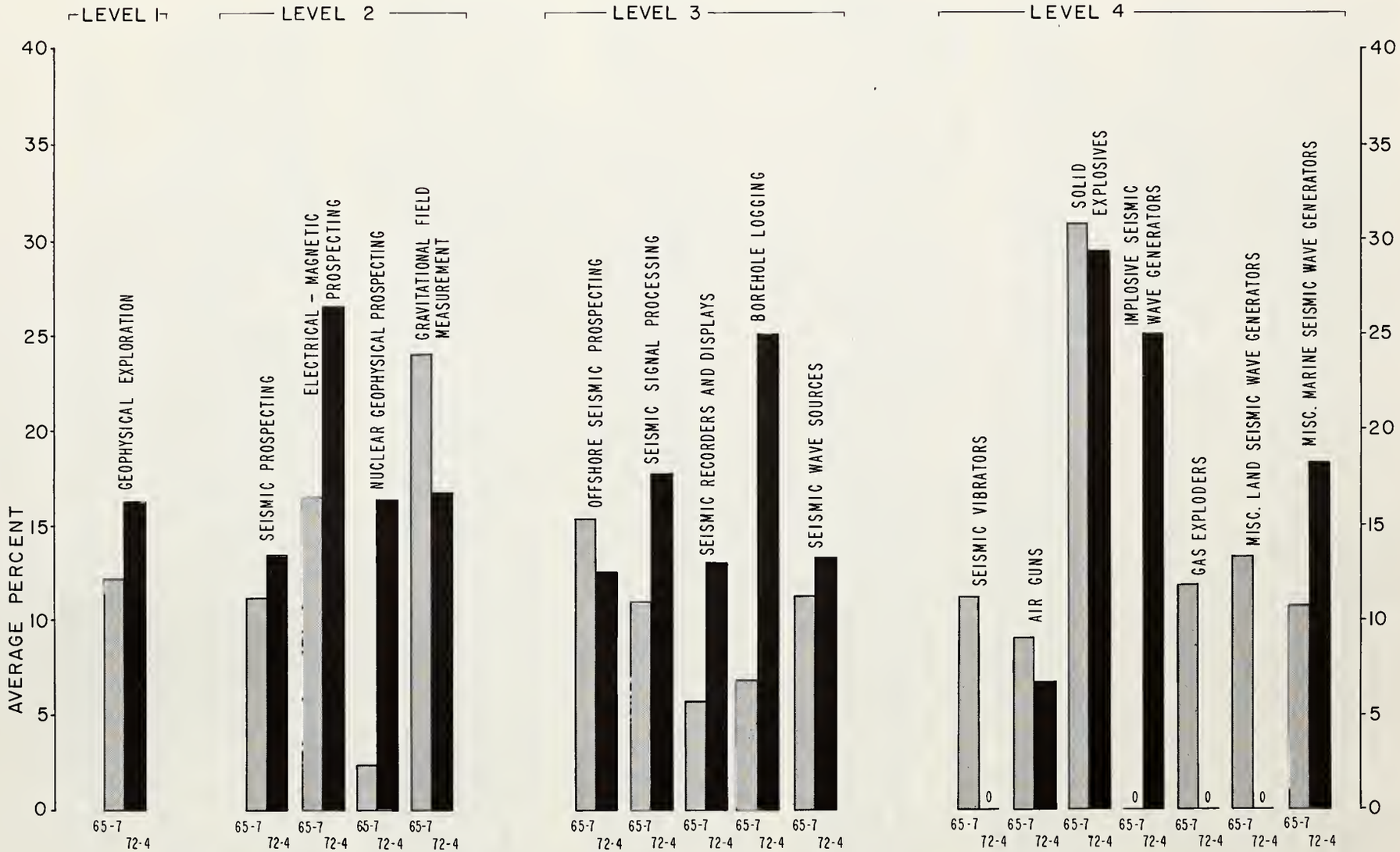
The percentage of geophysical exploration patented applications granted to foreign resident inventors at each level of the technology is shown for two time periods in Figure 3-1. The results are expressed as a three year average percent foreign of all patented applications filed in a given area during the periods 1965-1967 and 1972-1974, respectively.

In level 1, geophysical exploration, an increase in foreign patenting of only 4.2% has occurred. However, dramatic increases have taken place in nuclear exploration and electrical-magnetic prospecting (Level 2), seismic signal processing, seismic recorders and displays and borehole logging (Level 3) and the implosive seismic wave generators and miscellaneous marine seismic wave generators of Level 4. These increases represent sizeable inroads, by foreigners, into these presently prominent areas of geophysical exploration.

The pie diagrams of Figure 3-2 show, in geophysical exploration and three of its components*, the country breakdown of U.S. patenting by foreign inventors. For comparison purposes, the smaller central pie chart shows this breakdown for all U.S. patented technologies. For all technologies, Japan is the leading foreign inventor country (24.3%) while the Federal Republic of Germany is a very close second (24%). France is a distant fourth with only 9.5%.

---

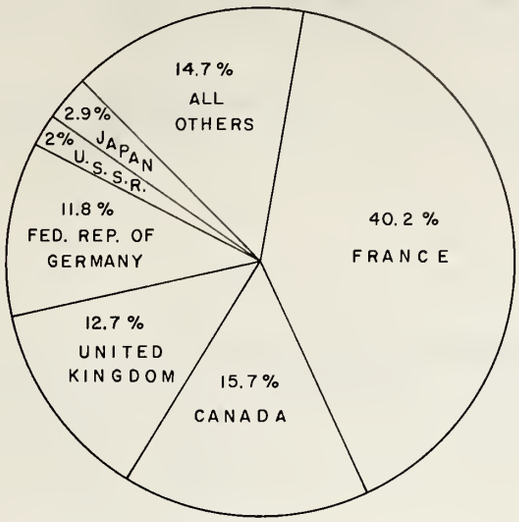
* Gravitational field measurement has been omitted due to its recent, extremely low level of patenting.



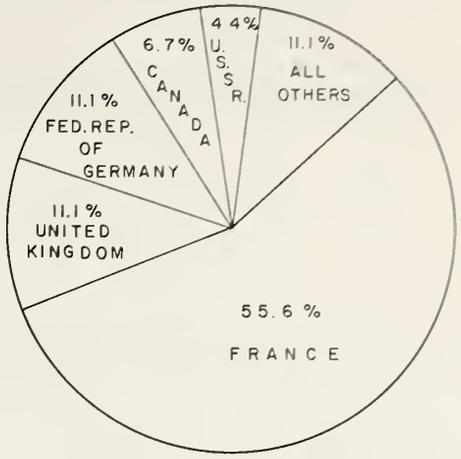

FOREIGN SHARE OF U.S. PATENTING IN ALL LEVELS OF GEOPHYSICAL EXPLORATION
1965-1967 & 1972-1974

FIG. 3-1

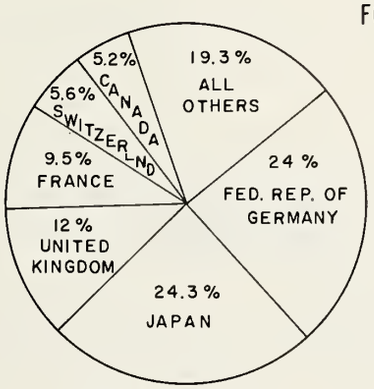
# FIG. 3-2 : U.S. PATENTING BY RESIDENTS OF FOREIGN COUNTRIES 3 YEAR AVERAGE (1972-1974)



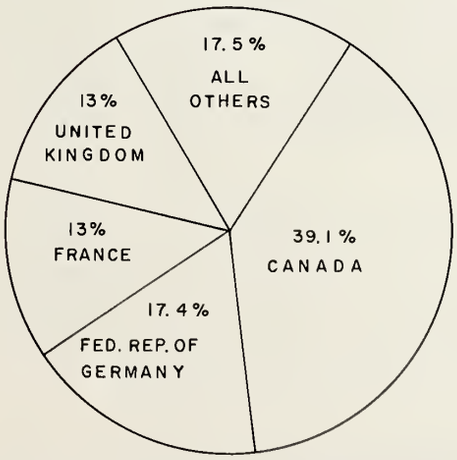

GEOPHYSICAL EXPLORATION
(LEVEL 1)
FOREIGN SHARE 16.2 %



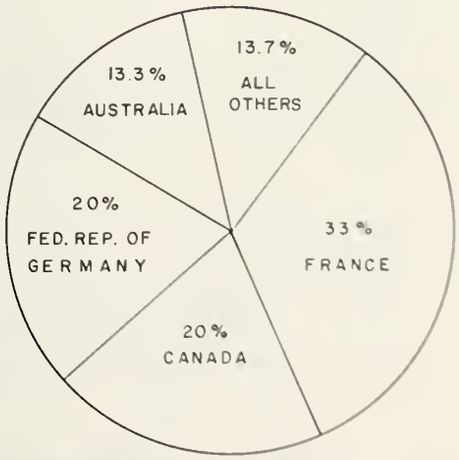

SEISMIC PROSPECTING
(LEVEL 2)
FOREIGN SHARE 13.4 %




PATENTS IN ALL
TECHNOLOGIES
FOREIGN SHARE 35.0 %




ELECTRICAL-MAGNETIC PROSPECTING
(LEVEL 2)
FOREIGN SHARE 26.4%




NUCLEAR PROSPECTING
(LEVEL 2)
FOREIGN SHARE 16.3%

However, in geophysical exploration technologies, foreign inventors based in France comprise the single largest group of non-U.S. inventors. In the last decade French inventors have received more than double the number of U.S. patents received by Canadian inventors, the country with the next largest number of U.S. patents granted to its residents.

It is interesting to note that Japan, the most active foreign country in total U.S. patenting with 24.3% is only seventh in patenting directed to geophysical exploration with 2.9%.

B. OVERALL PATENT ACTIVITY

Level 1: Geophysical Exploration Methods and Systems

Figures 3-3 through 3-5 illustrate the patent activity in the Level 1 and 2* areas of geophysical exploration. The first two figures show the number of total patented applications filed in geophysical exploration and seismic prospecting, by year, from 1965-1974, and the activity in these areas as a percentage of total patented applications filed in all technologies, by year, from 1965-1974.

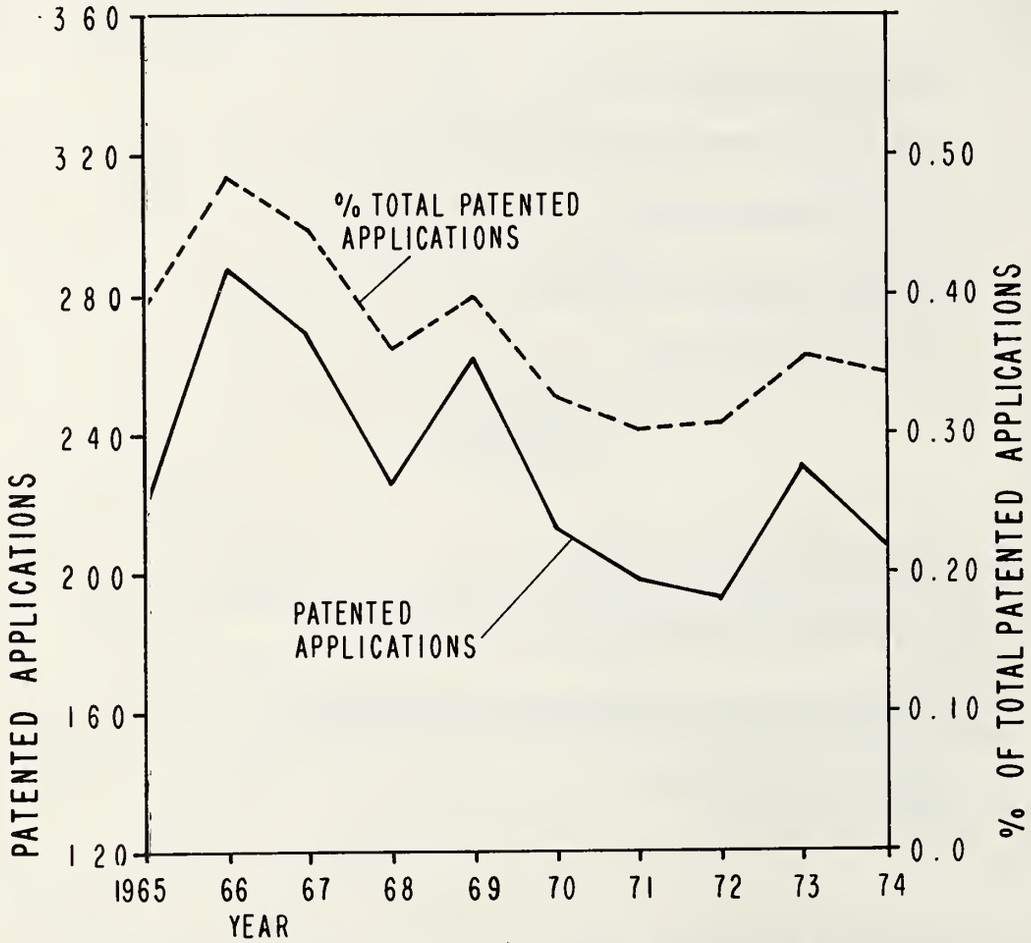



FIG. 3-3 : PATENT ACTIVITY IN GEOPHYSICAL EXPLORATION

---

* Gravitational field measurement has been omitted due to its recent, extremely low level of patenting.

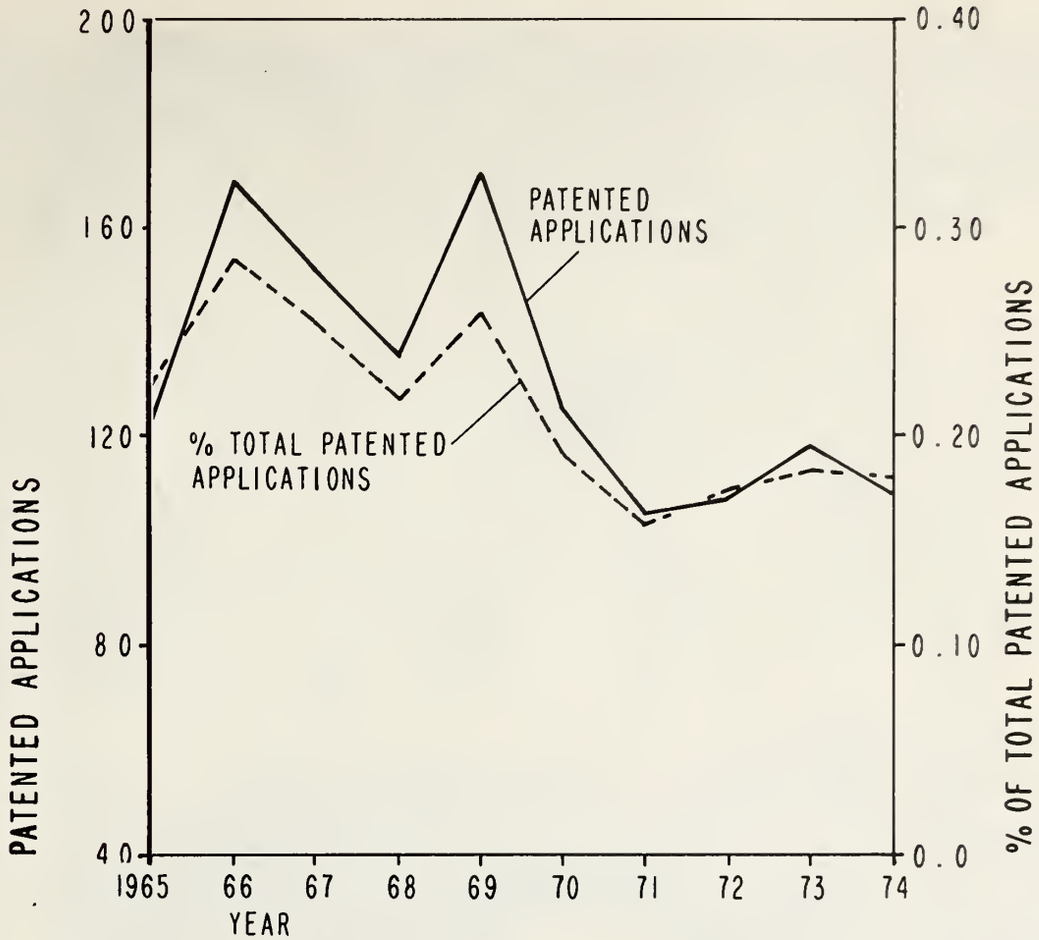



FIG. 3-4 : PATENT ACTIVITY IN SEISMIC PROSPECTING

The number of patented applications per year in the broad geophysical exploration area varied from a high of 287 in 1966 to a low of 193 in 1972, and averaged 230 over the 10 years investigated. On a percentage basis, these patents represented an average of .372% of all patented applications granted from 1965-1974; the high being .482% in 1966 and the low being .302% in 1971.*

The number of patented applications in the seismic prospecting area varied from a high of 170 in 1969 to a low of 105 in 1972, and averaged 131 over the 10 years investigated. On a percentage basis, the patents represent an average of .212% of all patented applications granted from 1965-1974; the high being .284% in 1966 and the low being .159% in 1971.

---

* It is interesting to note that, in this technology, patenting by application filing date correlates very closely to that of patenting in all technologies. The correlation coefficient ($R^2$) for a linear regression between patented applications in geophysical exploration and patented applications in all technologies is .72, an extremely high value for any particular technology.

Figure 3-5 (below) shows the activity in electrical-magnetic and nuclear prospecting as a percentage of total patented applications filed in all technologies by year, from 1965-1974. The total number of patented applications filed by year in these two areas is available in their respective examiner reports in Part 2.

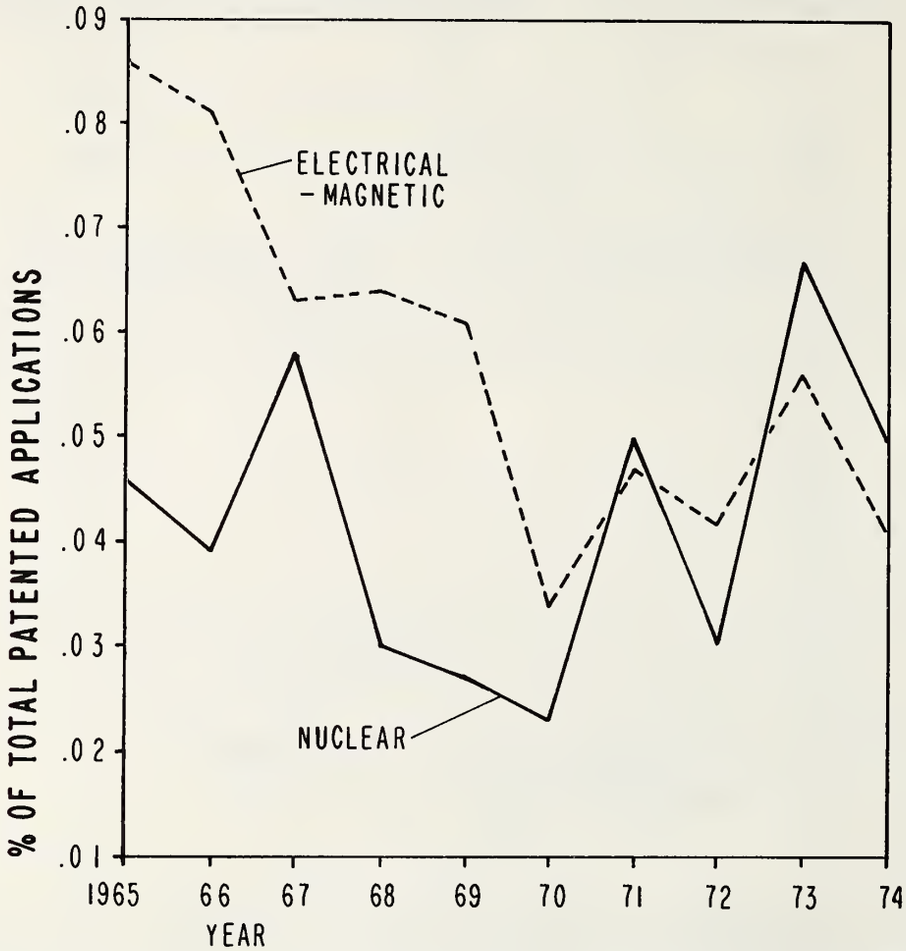



FIG.3-5 : PATENT ACTIVITY IN ELECTRICAL-MAGNETIC AND NUCLEAR PROSPECTING

In the electrical-magnetic prospecting area the number of patented applications from 1965-1974 represent, on a percentage basis, an average of .058% of all patented applications granted from 1965-1974; the high being .086% in 1965 and the low being .034% in 1970. In the nuclear prospecting area the number of patented applications from 1965-1974 represent, on a percentage basis, an average of .042% of all patented applications granted from 1965-1974; the high being .067% in 1973 and the low being .023% in 1970.

The declining level of patenting in the broad geophysical exploration area and the seismic and electrical-magnetic prospecting subcomponent areas during the 1969-1972 period coincides with a general decline in the number of patent applications during this period and a worldwide decline in geophysical exploration activity during the period, as well.*

---

* Geophysics, special reports, 1970, 1971, 1972, 1973 and 1977

Level 2: Seismic Prospecting, Electrical-Magnetic Prospecting, Nuclear Geophysical Prospecting and Gravitational Field Measurement

In Figure 3-6, the relative patent activity of the four level 2 modes of geophysical exploration are analyzed and compared. The data are expressed as the percent of all geophysical patented applications for each year from 1964-1975. (1964 and 1975 values are provided in this Figure since enough data are available to give percentage estimates for these years.)

Over the 10 years investigated, a noteable change which may presage a trend, is the apparent growth of innovations in nuclear prospecting. In 1964 nuclear prospecting accounted for only about 11% of all geophysical exploration patents. This increased to about 17% a decade later. Patented applications directed to seismic prospecting decreased from about 72% in the 1964 to about 64% in 1975. However, because of the wide patenting fluctuations in this area during the period, it is difficult to determine whether this change is significant or only temporary. Patented applications directed to electrical and magnetic modes of prospecting have remained fairly consistent from 1965-1975, having increased only 2% in a decade. Patenting in gravitational field measurement has practically stopped, with only one patented application in the last three years.

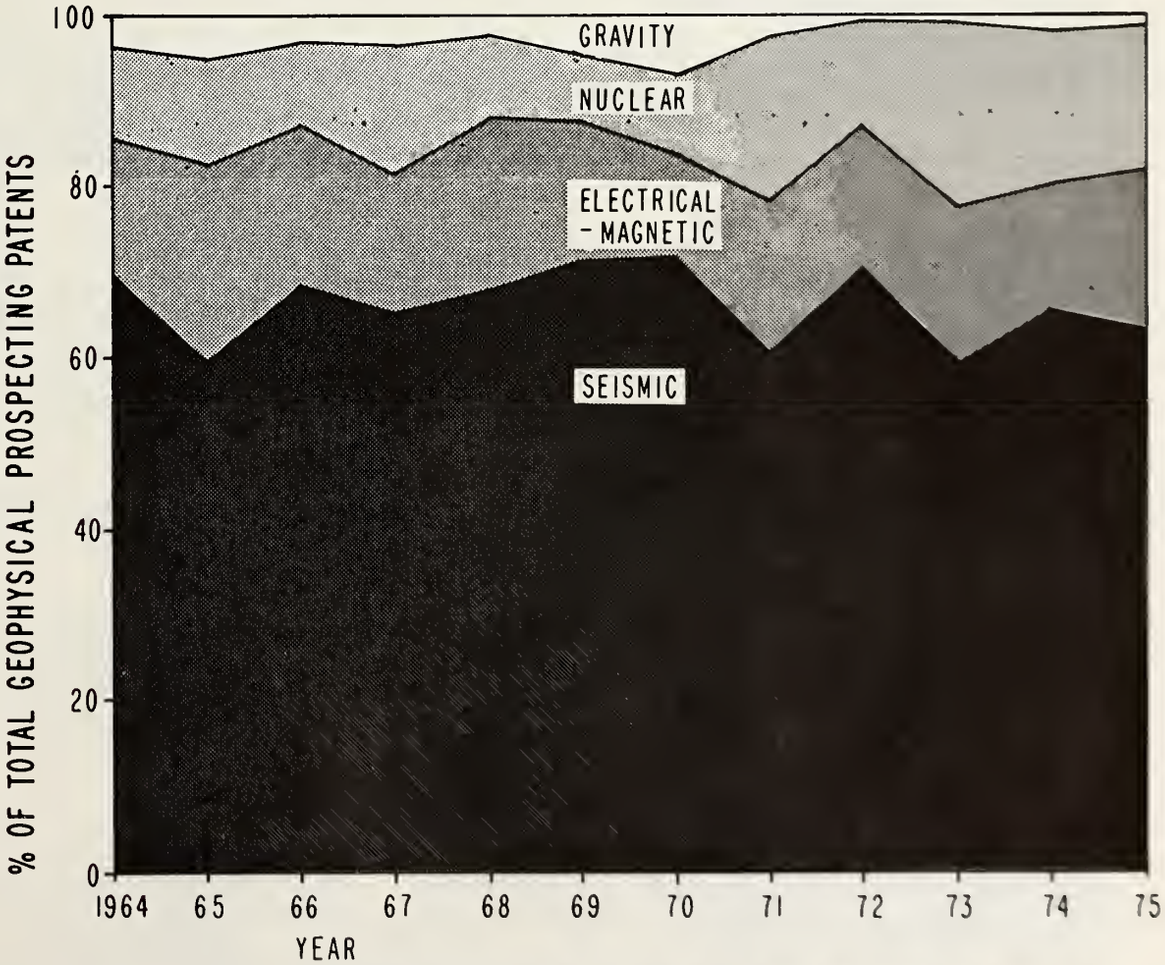



FIG. 3-6 : RELATIVE PATENT ACTIVITY OF THE LEVEL 2 MODES OF GEOPHYSICAL EXPLORATION

## C. CORPORATE PATENT ACTIVITY*

What firms are obtaining patents in the geophysical exploration area? As expected, the large oil companies (Mobil, Texaco, Shell, Continental, etc.) are obtaining the major share. However, as shown in Figure 3-7, The Schlumberger Technology Corporations own the largest share of patents in geophysical exploration. Schlumberger's 13% share of all of the patents issued in geophysical exploration is more than twice that of the next largest patent assignees, Mobil or Texaco, each of which have 6% of the total patents in this area. Schlumberger also leads in patenting in each of the level 2 categories, seismic -9%, electrical-magnetic -22%, and nuclear -22%. In the level 3 categories, Schlumberger is the leader in, and owns almost one quarter of the patents issued in borehole logging. It is second to Mobil with 17% of the patents in seismic recorders and displays, and fourth with 5% of the patents in offshore seismic prospecting. The sole area, of all the levels considered, that Schlumberger does not appear as a major assignee is that of seismic wave sources.

In the seismic wave source area the United States of America, as assignee, led with a 19% share, and of these, the U.S. Navy led in percent of U.S. government assigned patents with 17 of the 19%.

In the offshore seismic prospecting area, Texas Instruments Inc. led with 11% of the assigned patents.

Among the major oil companies Texaco and Mobil were about equally active in the level 1 area of geophysical exploration. However, Mobil led in the the level 2 area of seismic prospecting, and the level 3 areas of seismic signal processing, seismic recorders and displays and borehole logging.

## D. GENERAL ANALYSIS

In Figure 3-8, activity in the seismic mode of prospecting is compared both by field usage, measured in line-miles explored, and by innovations, measured by the number of patented applications. Seismic prospecting was selected for this comparison in view of its relatively large share of the level 1 area of geophysical exploration and the ready availability of field usage data in the area.

The figure shows the number of line miles (in thousands) of seismic prospecting for each of the years from 1965-1974 and the number of patented applications for the same period.

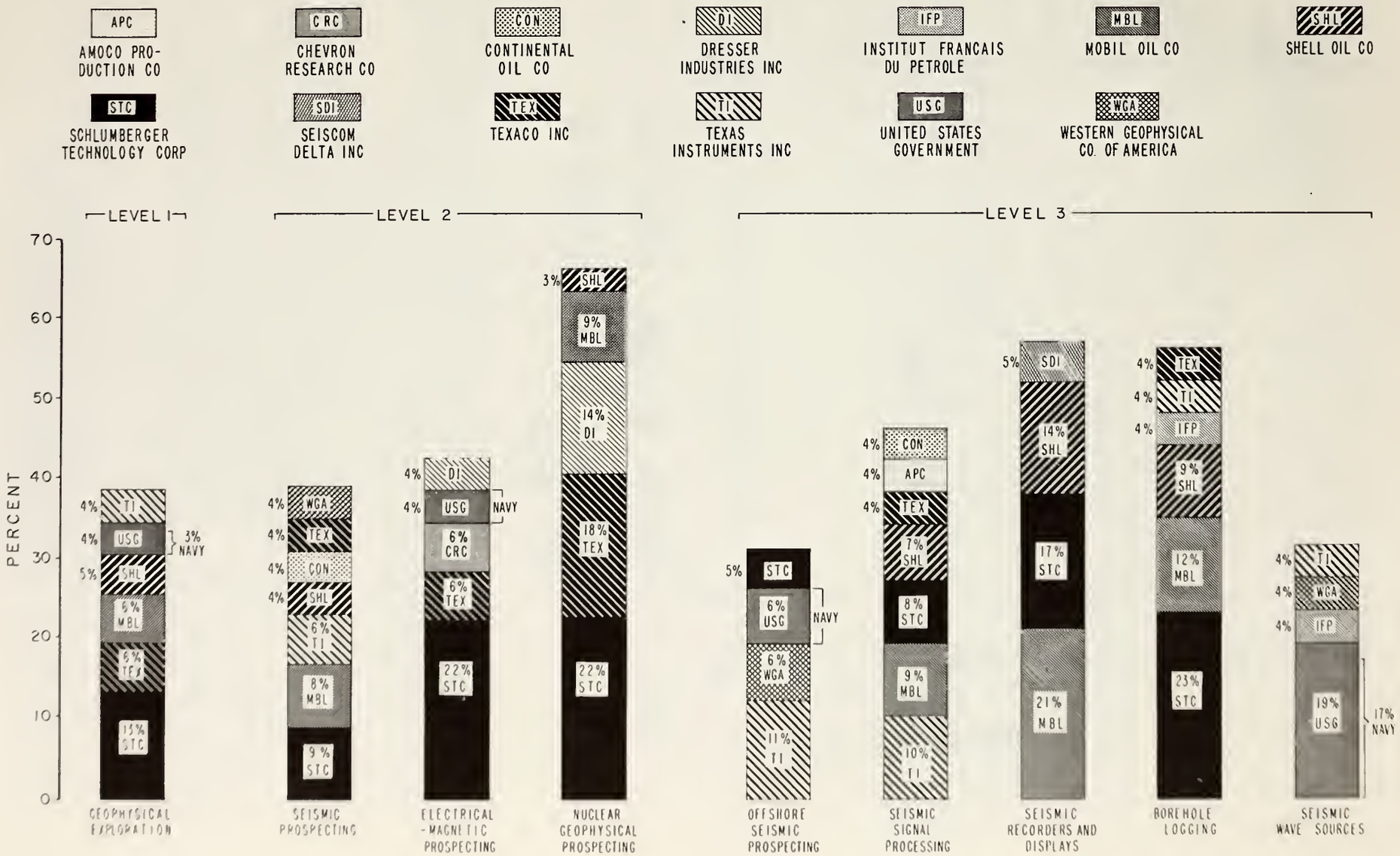
A correlation between the number of line miles and the number of patented applications over the 1965-1974 period is evident from the figure. An assessment of this correlation is that the increase in field use of seismic prospecting methods and apparatus spurs a concomitant increase in the number of innovations and inventions in seismic prospecting.

---

*Patenting for corporations mentioned in this section includes that of subsidiaries, where they could be identified. For example, Schlumberger Technology corporations is composed of the following companies: Schlumberger Instruments ET Systemes; Schlumberger Limited; Schlumberger N.V.; Schlumberger Overseas Messgeraebau Und Vertrieb; Schlumberger Technology Corporation; Schlumberger Well Surveying Corporation; Schlumberger, N. & CIE.

FIG. 3-7

# PATENTING BY MAJOR CORPORATIONS IN GEOPHYSICAL EXPLORATION TECHNOLOGIES
January 1969 - January 1977



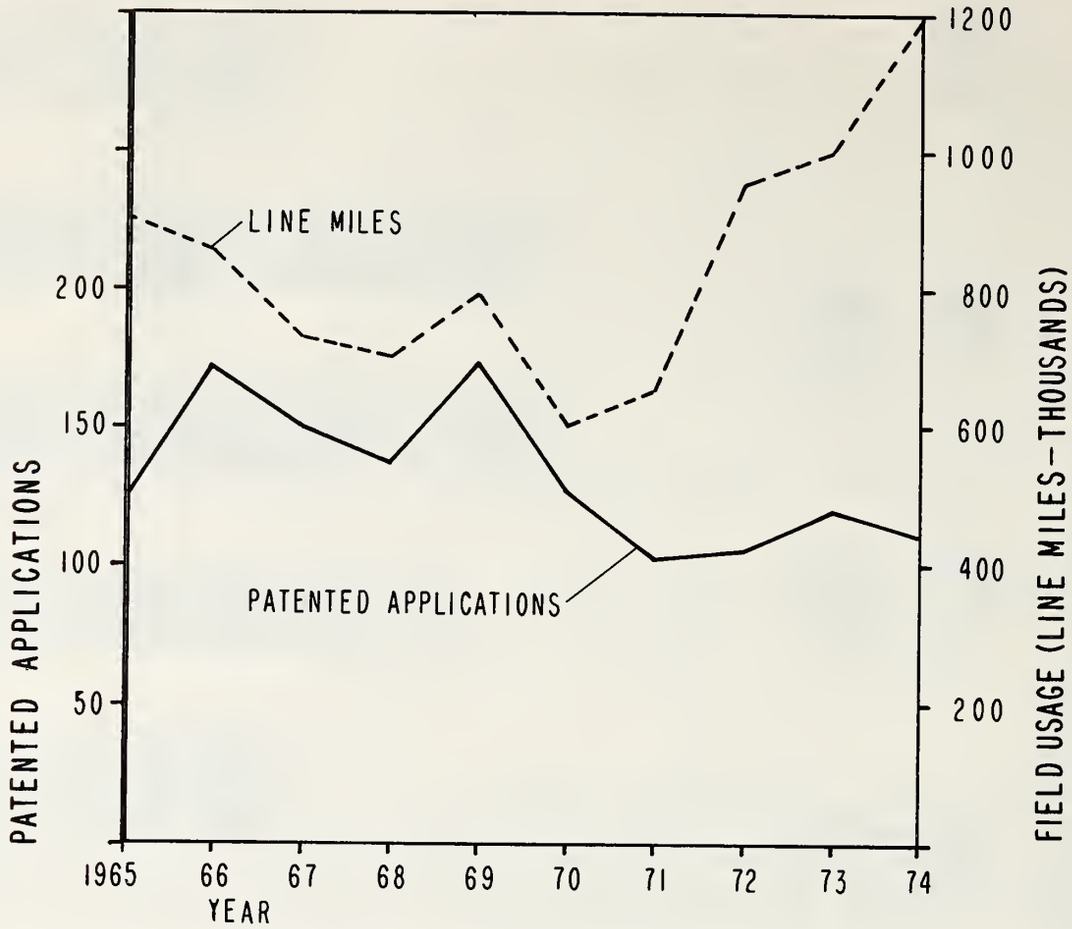



FIG. 3-8 : PATENTING IN SEISMIC PROSPECTING VS. WORLD-WIDE SEISMIC ACTIVITY IN LINE-MILES

The relatively small decrease in patented applications in 1974 may, in part, be attributable to incomplete data for that year. While patented application data is felt to be essentially complete through 1974, it is recognized that not all applications of that year may have been patented as of December 31, 1976, the closing date for the patent statistics used.

In the "mini-reports" in Part 2 of this Section, which follows, the distribution of patenting by application filing date for the Level 4 area of seismic wave sources, indicates trends in the development of certain seismic wave generators. For example, patenting in the area of seismic vibrators has varied from a low of one patented application in 1965 and one in 1969 to a high of 8 in 1973. From 1970-1974, this area averaged 5.6 patented applications per year. This comparatively large increase in the rate of patenting over these time periods is indicative of the development of the vibrator as a major seismic wave source.

Developments in the use of solid explosives as a seismic wave generator is, on the other hand, indicated to be decreasing. From 1967-1969 this area averaged 14 patented applications per year; while, from 1970-1974, the average was only 5.8 patented applications per year.

Gas exploders are similarly indicated to be in a declining stage of development. From 1967-1969 gas exploders averaged 14.3 patented applications per year, while from 1970-1974 this area averaged only 5.4 patented applications per year.

Air gun seismic wave generators have maintained a fairly steady pace of development having averaged 5.3 patented applications per year from 1967-1969 and 5.4 patented applications per year from 1970-1974.

The relatively new area of marine implosive seismic wave generators has a non-uniform rate of patenting by application date. For both 1967 and 1973 no patent applications for this area were issued. Yet for 1974 the largest number of patented applications per year for this area were issued -- five.

In the miscellaneous seismic sources area, the land sources are indicated to be in a high rate of development while the marine sources are indicated to be in a declining rate of development. The land sources averaged 3.3 patented applications per year from 1967-1969 and 9 patented applications per year from 1970-1974. The marine sources, on the other hand, averaged 10 patented applications per year from 1967-1969 and 4.2 patented applications from 1970-1974.

Technology Analysis by
Nelson Moskowitz
Patent Examiner

# PART II

# REVIEW OF SELECTED GEOPHYSICAL EXPLORATION TECHNOLOGIES

# ELECTRICAL AND MAGNETIC PROSPECTING*

Two major techniques used in geophysical exploration are magnetic and electrical prospecting. In magnetic prospecting, variations in the earth's magnetic field are measured. These variations indicate the existence of certain geologic structures in the formation lying below the earth's surface. In electrical prospecting, electrical properties of earth formations are measured to provide a clue to the nature of the geologic structure situated below the surface. Magnetic and electrical surveys, in one form or another, may be carried out on the ground, under water, in the air or within boreholes extending thousands of feet below the earth's surface.

In the ongoing search for mineral and hydrocarbon deposits, which has never been as important as it is now in today's energy crisis, electrical and magnetic techniques for geophysical exploration play a major role.

In the most recent three year period (1974-76) 102 patents have issued in the technology. This is 24.4% of all electrical and magnetic prospecting patents received in the last ten years. This patent activity is illustrated by both patent grant data and application filing date of these patents, in the graphs on the following page.

Since 1974, the foreign contribution to this technology's growth has amounted to 24.5% of all U.S. patents issued, significantly less than the all technology foreign share average of 35.2% for the same period. The distribution of patents in this technology by country of origin is shown in the table following the graph.

## Thrust of the Technology

### Magnetic Prospecting

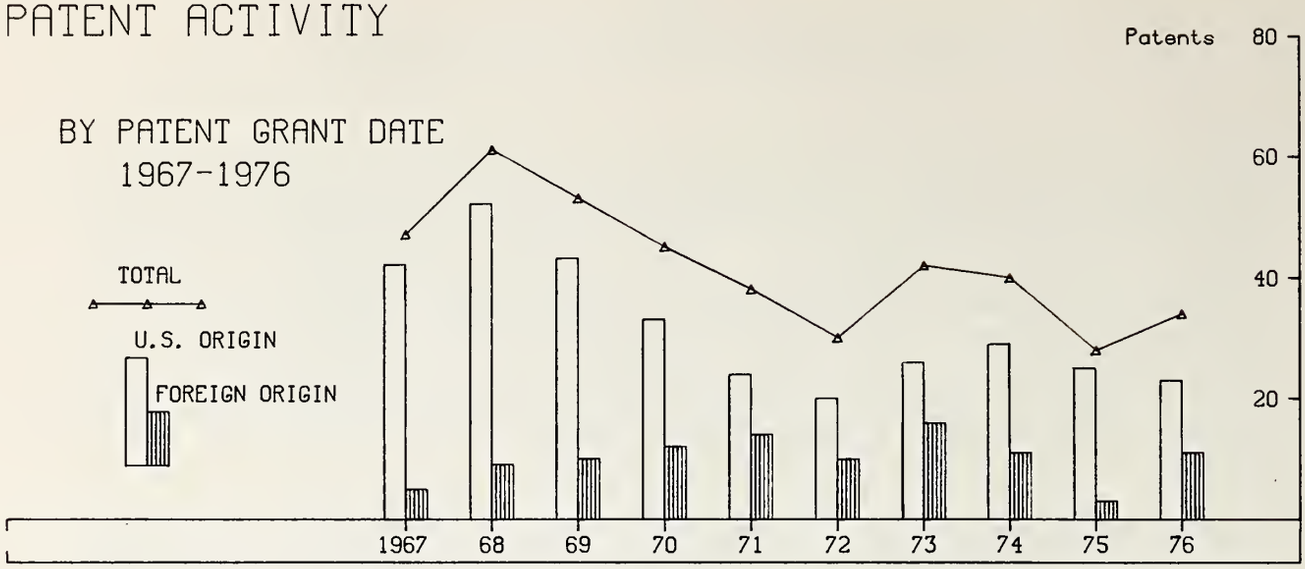
Magnetic prospecting is one of the oldest methods of geophysical exploration, dating back in its most primitive form, to the 17th century. The basis of this technique is the fact that the earth's magnetic field at any point is a function of the geologic structure at that point.

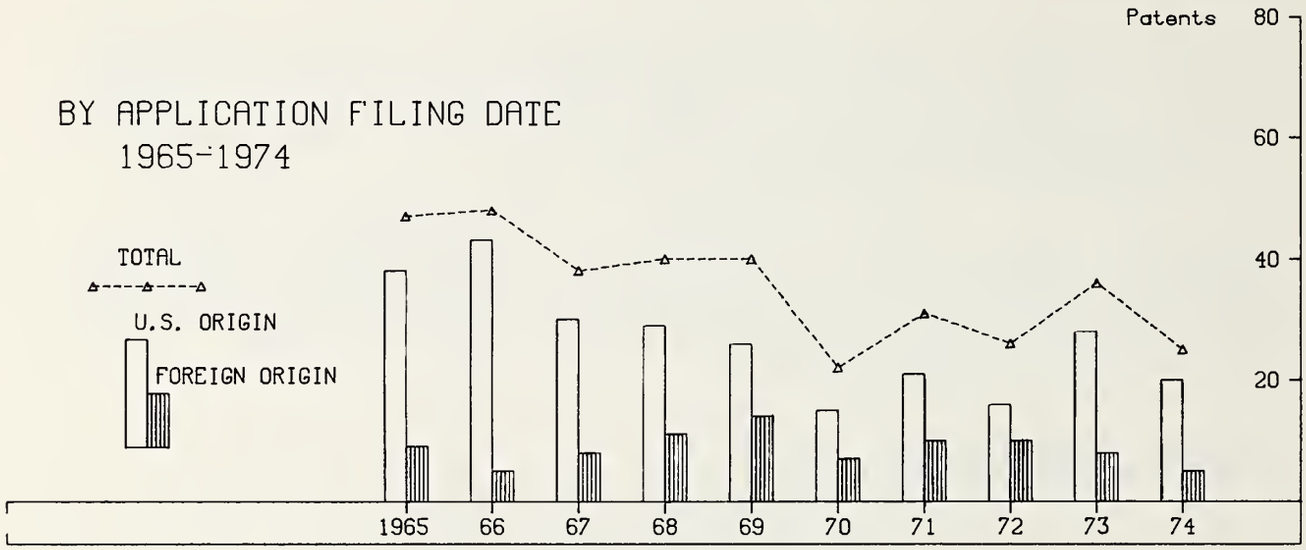
The unit of magnetic field measurement in magnetic surveying is the gamma, which is equal to $10^{-5}$ oersted. The magnetic field of the earth and that of the geologic bodies lying therein is expressed in terms of the magnitude and direction of the total field intensity vector T. The total field in-

---

* The technology described in this report is contained in U.S. Patent Classification System Class 324, subclasses .5G, 1 and 3-10 and selected patents from Class 324, subclass .5E.

# PATENT ACTIVITY




## DISTRIBUTION OF PATENTS IN AREA OF INTEREST

| | BY PATENT GRANT DATE | | | | | | | | | | TOTAL | BY PATENT APPLICATION FILING DATE | | | | | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1967 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 67-76 | 1965 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 65-74 |
| TOTAL PATENTS | 47 | 61 | 53 | 45 | 38 | 30 | 42 | 40 | 28 | 34 | 418 | 47 | 48 | 38 | 40 | 40 | 22 | 31 | 26 | 36 | 25 | 353 |
| UNITED STATES | 42 | 52 | 43 | 33 | 24 | 20 | 26 | 29 | 25 | 23 | 317 | 38 | 43 | 30 | 29 | 26 | 15 | 21 | 16 | 28 | 20 | 266 |
| TOTAL FOREIGN | 5 | 9 | 10 | 12 | 14 | 10 | 16 | 11 | 3 | 11 | 101 | 9 | 5 | 8 | 11 | 14 | 7 | 10 | 10 | 8 | 5 | 87 |
| CANADA | 2 | 3 | 2 | 4 | 9 | 1 | 5 | 3 | 3 | 4 | 36 | 4 | | 3 | 4 | 7 | 2 | 3 | | 6 | 3 | 32 |
| FRANCE | 1 | 3 | 7 | 3 | 2 | 4 | 2 | 3 | | 3 | 28 | 3 | 5 | 2 | 4 | 2 | 2 | 2 | 2 | 1 | | 23 |
| GERMANY | 2 | 1 | 1 | 1 | | 2 | 4 | 1 | | | 12 | | | 2 | | 1 | 1 | 1 | 4 | | | 9 |
| UNITED KINGDOM | | | | 1 | | 1 | | 2 | | 3 | 7 | | | | 1 | | | 2 | 1 | | 2 | 6 |
| U.S.S.R. | | 1 | | 2 | | 1 | 3 | | | 1 | 8 | 1 | | 1 | 1 | 1 | 1 | 2 | | | | 7 |
| JAPAN | | | | | 1 | | 1 | | | | 2 | | | | | 1 | | | 1 | | | 2 |
| SWITZERLAND | | | | | | | 1 | 1 | | | 2 | | | | | | | | 2 | | | 2 |
| ITALY | | | | 1 | | | | | | | 1 | | | | 1 | | | | | | | 1 |
| SWEDEN | | | | | 1 | 1 | | 1 | | | 3 | | | | | 1 | 1 | | | 1 | | 3 |
| ALL OTHER (3) | | 1 | | | 1 | | | | | | 2 | 1 | | | | 1 | | | | | | 2 |

tensity vector may be resolved into its horizontal (H) and vertical (Z) intensity components. H in turn may be resolved into its X (north) and Y (east) components. The angle between H and T is known as the inclination (I) and may be defined as H=T cos I or tan I=Z/ZH. The declination, D, which is the angle between the magnetic north direction and the astronomic (true) north may be expressed in terms of the horizontal intensity (H) components X and Y as tan D=Y/X. Although modern instruments can now measure the total field intensity, earlier measuring devices separately measured the various components of total field intensity.

Pivoted needle instruments were among the earliest devices used in magnetic exploration and included such types as the Swedish Mining Compass, the Hotchkiss Superdip, and the Thalen-Tiberg magnetometer. These pivoted needle devices, as the name implies, utilized a magnetic element in the form of a needle, positioned so as to rotate on pivots in response to an external magnetic field. Although widely used for many years, such instruments were limited in their range of application due to a lack of adequate sensitivity.

The art of magnetic prospecting experienced a significant breakthrough from 1913 through 1917 with the development by Adolph Schmidt of a vertical magnetometer. Schmidt's device, a precision type portable magnetometer, able to measure small magnetic field variations, utilized a permanent magnet system balanced on a knife edge as its sensing element. While the prior art devices were primarily limited to searching for magnetite ore, Schmidt's instrument opened up exploration to the discovery of many other geologic structures.

Variations on Schmidt's magnetometer and other types of magnetic field measuring instruments (e.g., the magnetic torsion balance, magnetron, earth inductors and iron-induction) were developed in the ensuing years, providing a variety of instruments for magnetic prospecting. Although relatively accurate, these instruments could only be used in relatively slow moving transport systems. Surveying with them was tedious and slow. What was needed was an instrument which could be used in rapidly moving transport systems to carry out surveys over vast regions at a rapid pace.

Just prior to World War II, Vacquier, Muffly and Wyckoff developed a flux-gate magnetometer for use in aircraft (1-3).* Basically the flux-gate magnetometer is composed of two series connected primary coils wound in opposition around a pair of parallel cores aligned in the direction of the earth's field. When the coils are energized the two cores are magnetized in opposite directions. Absent any external field the coils are balanced. In the presence of an external field, the field of one of the coils is enhanced while the field of the other is diminished, creating an imbalance which is detectable at the outputs of a pair of secondary coils wound around the cores.

---

* Numbers in parentheses refer to patents listed in the Bibliography at the end of this report.

Although used in World War II primarily for submarine detection, the airborne flux-gate magnetometer opened up new horizons for geophysical exploration. Unencumbered by the need for rotating sensing elements, the flux-gate magnetometer revolutionized magnetic prospecting. Surveys of vast regions could now be accomplished in a fraction of the time previously taken.

In the early 1950's progress in the art of magnetometers developed from different phenomena than had previously been considered. Varian developed a total field proton magnetometer based on the principle of nuclear magnetic resonance (4). The magnetometer made use of the precessional frequency of oriented protons in a magnetic field which is proportional to the applied field intensity.

Following the innovation of the proton magnetometer, other magnetic field measuring devices were developed based on the nuclear resonance phenomena, including the rubidium vapor (5), cesium vapor (6), and the helium (7) magnetometers.

The nuclear resonance type magnetometer has further increased the precision and versatility of magnetic field measuring instruments. Some models are alleged to have a sensitivity of .005 gamma and are adaptable for use in the air, on the ground, under water or within a borehole.

Now that extremely precise magnetometers exist, different techniques are continually being developed for their actual field use. For example, Ruddock et al employ a pair of vertically spaced magnetometers suspended from a helicopter. Spatial derivatives of the intensity of a magnetic field are measured as an indication of the depth and fall off rate of subsurface magnetic anomalies (8). Zurflueh employs a pair of magnetometers spaced along the direction of travel of the transport means and correlates the measurements to provide a single measurement free from time variations (9). Yungul makes use of a highly sensitive magnetometer to determine the geologic age of the segment of a formation surrounding a borehole by measuring the remanent magnetization of the formation (10). McLaughlin et al, in the search for magnetic or conductive bodies, propose to detect time transients of the earth's magnetic field within a frequency range of 1-20,000 hertz (11).

## Technology Trends

Current developments in magnetic prospecting involve the use of superconducting magnetic field sensors which allegedly have the versatility of flux gate and nuclear resonance magnetometers, yet possess greater sensitivity (12).

## Electrical Prospecting

Numerous electrical exploration techniques have been developed, yet they have had limited application because of their lack of effectiveness at extreme depths below the earth's surface. Electrical methods can be divided into two groups: those which depend on naturally occurring fields and currents within the earth, such as the self potential, telluric and magnetotelluric methods; and, those which depend on the artificial introduction of currents and fields in the earth, such as the resistivity, potential profile, induced polarization, and electromagnetic methods. Electrical exploration, like magnetic prospecting, may be carried out on the ground, in the air, under water and below the earth's surface.

Above ground electrical surveys are used more for mineral deposit investigation than for oil prospecting. However, the adaptability of certain electrical techniques to a borehole environment presents a useful tool in the discovery of hydrocarbon deposits within the formations surrounding a well bore. While certain electrical techniques are limited in their operational procedures, electromagnetic processes are adaptable to airborne, ground and borehole exploration.

In the search for mineral bodies, the self potential technique dates back to the early part of this century and involves the measurement of naturally occurring electrical potentials on the ground or within a borehole (13, 14). These potentials are of electrochemical origin, being derived from electrochemical actions among the mineral bodies and the solutions contacting them.

The telluric current method relies on the measurement of potential differences at the earth's surface caused by telluric current flow. Telluric currents are naturally occurring variable currents which permanently circulate in vast sheets within the outermost layers of the earth's crust. The source of such currents is believed to be astronomic in nature, caused primarily by electromagnetic phenomena of ionospheric origin. The distribution of these telluric currents is determined by the resistive nature of the formations through which they flow. Thus any resistive anomaly will cause a disturbance in the telluric current flow pattern which can be detected at the earth's surface by measuring the potential gradients associated therewith. As shown in Figure 1, in field operation, telluric measurements are obtained at different stations, at a predetermined frequency or bandwidth and compared over a selected period of time. Much of the early

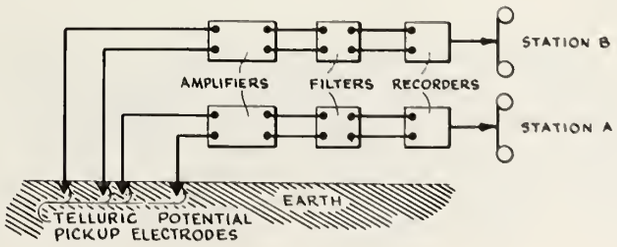



*FIG. 1: TELLURIC CURRENT PROSPECTING*

(1930's) work in telluric prospecting was done by Schlumberger, who established the basic technique of comparing the telluric current potentials at different stations (15, 16). Later Kunetz (17) expanded on this technique and Yungul introduced a collinear three electrode array and Fourier analysis techniques into the measurement of telluric potentials, which contributed to the development of telluric prospecting (18, 19).

Cagniard (20) in the early 1950's proposed to compare variations occurring in the electric telluric field in a given area over a given period of time with variations occurring in the magnetic field of the earth in that area. This technique, which is based on the fact that magnetic field variations occurring at the earth's surface are not independent of variations in direction and intensity of telluric currents, became known as the magnetotelluric method. Developments in this method, such as Cagniard's submarine technique for magnetotelluric prospecting are presently continuing (21).

Most electrical prospecting methods, unlike those discussed above, rely on the use of an artificial source of energy. The resistivity method is among the oldest of these types, employing direct, commutated or low frequency alternating currents to determine the resistivity distribution of the subsurface formations. Since the earth's resistivity is not uniform, apparent resistivity is determined rather than true resistivity.

In practicing the resistivity technique, an electric current is passed into the earth formations between a first pair of electrodes embedded in the earth while the resulting potential is measured between a second pair of embedded electrodes. The electrodes are usually arranged in a straight line configuration. Electrode arrays often differ with regard to electrode spacing and position of the current electrode pair in relation to the potential pickup electrode pair. Early basic configurations included current electrodes, symmetrically spaced along a line outside the potential electrodes (Wenner and Schlumberger (22) arrangements). A later developed configuration utilized the current electrode pair spaced a considerable distance from the potential electrode pair (23).

Various operational procedures may be applied to these arrays. For example, the entire electrode array, while maintaining a fixed separation between electrodes, may be moved laterally, in toto, along the ground to provide a horizontal profile of subsurface resistivity variations (22). Alternatively, the spacing between current electrodes or voltage electrodes may be varied to provide an indication of resistivity variation with depth (24). While modifications in the basic configuations and their applications have been introduced over the years, the underlying principles involved remain the same.

The resistivity method has also been adapted to well logging by supporting the electrodes on a logging instrument adapted to be moved within a borehole. In this manner the resistivity of the formations along the borehole can be determined. There are numerous types of electrode configurations used with such instruments, and over the years the electrode arrays and the circuitry have become complex. Today these

instruments include extensions of the so-called focusing electrode arrangements (25) wherein current is forced to flow horizontally for some distance into the formations surrounding the borehole, by means of guard electrodes situated on each side of the current emitting electrode (26, 27).

Other electrical methods utilizing the introduction of current into the ground include equipotential line survey (28) and potential drop-ratio methods (29).

In the 1950's and 60's a field procedure known as the induced polarization method gained widespread recognition in the field of electrical prospecting (30). Induced polarization is the term used in referring to the phenomena which occurs with respect to certain types of conducting minerals, located within a formation zone, in the presence of an externally applied current source. In passing an electric current through the zone an electrochemical barrier in the form of an opposing voltage is produced at the interface between a mineral body and the surrounding electrolyte. (The mineral is said to be polarized at the interface). In order to overcome this polarization effect an added voltage known as the "overvoltage" is necessary to drive the current across the barrier. When the current is turned off, the overvoltages which were set up decay in time. Observation of these voltages provides an indication of the nature of the minerals within a particular zone of investigation. In addition to time domain studies, induced polarization measurements can also be made in the frequency domain by comparing the effect of the overvoltages on alternating currents of different frequencies.

Seigel, having done considerable work with the induced polarization method, extended this procedure to include measurement of the magnetic field created by the applied polarization current, before and after termination of current flow, as an indication of the induced polarization characteristics of the medium under investigation (31). He later applied magnetic field measurements to frequency domain induced polarization studies (32).

Electromagnetic methods involve the creation of an electromagnetic field (called the primary field) which penetrates the earth's formations causing currents to be induced in conducting bodies present within the formations. These induced currents produce secondary fields which can be detected as a sign of the presence of such conducting bodies. An alternating current source, the frequency of which may vary from a few cycles per second to the megahertz range, coupled to a pair of grounded electrodes or a loop of wire (called the transmitter) is used to establish the electromagnetic field. A pick-up coil (called the receiver coil) can be used to detect the secondary field produced in the area of investigation. The resultant field (constituting the vector sum of the primary and secondary fields) may be detected, or, by cancelling the primary field, only the secondary field may be measured. In analyzing the detected field, various characteristics may be determined, including measurements of field amplitude and/or phase. The detected field can also be resolved into constituent parts such as in-phase and quadrature phase components.

Two categories into which electromagnetic methods are often divided include: (a) the method in which the primary field source is held stationary while the receiver system is moved over the area of investigation; and (b) the method in which both the transmitter and receiver are moved.

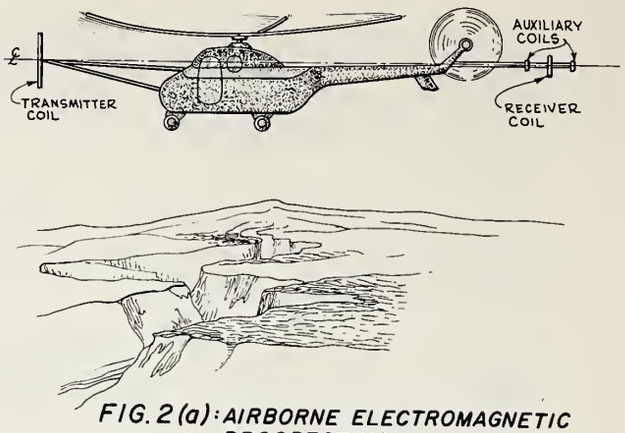



FIG. 2 (a): AIRBORNE ELECTROMAGNETIC PROSPECTING

By varying the frequency of the applied field or the separation between transmitter and receiver, responses from different depths below the surface may be obtained. In the development of these techniques, Sundberg as far back as the 1920's, provided early pioneering work in ground methods of electromagnetic prospecting (33-35).

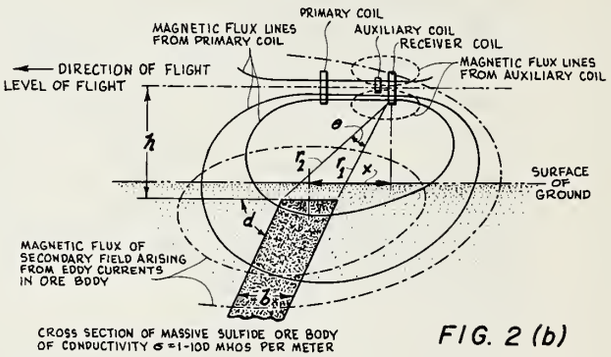



FIG. 2 (b)

However the electromagnetic methods are not confined to ground prospecting, but find considerable application in airborne use (wherein both transmitter and receiver are simultaneously moved). Over the years airborne systems such as the one shown in Figures 2 (a) and 2 (b) have been developed to deal with the problems of supporting the transmitter and receiver coils with respect to each other and the aircraft. Puranen, Khama, Ronka, Robinson, Ruddock, Cartier and McLaughlin in the past 25 years, have done considerable work in airborne electromagnetic prospecting (36-39).

In borehole investigation, another electromagnetic method used is the so-called induction logging system. In this system a logging tool, containing spaced transmitter and receiver coils, is moved along the borehole to provide a continuous profile of downhole characteristics, e.g., conductivity or susceptibility (40-43).

All of these electromagnetic methods rely on the use of continuous electromagnetic waves as the energy source. However, the use of transient pulses as an energy source has also been developed. In this method, the electromagnetic waves produced by short, abruptly terminated transient current pulses applied to a loop of wire or grounded electrodes are caused to penetrate the formations. The resultant voltage induced in a pick-up coil is measured as an indication of the presence of a conducting body (44). Barringer adapted a similar technique for use in an airborne system (45).

Other electromagnetic methods include observation at a receiver of the effects of subterranean features on the transmitter signal (46,47) and the use of radar techniques for mapping subsurface interfaces (48,49) and determining the distance to dielectric discontinuities from within a borehole (50).

## Technology Trends

In the area of electromagnetic borehole investigation there appears to be a trend toward increasing the frequency of the energizing fields. Recently, considerable work has been done utilizing frequencies from the low megacycle to microwave region of the electromagnetic spectrum.

Technology Analysis by
Gerard Strecker
Patent Examiner

# BIBLIOGRAPHY


| PATENT NO. | INVENTOR | ASSIGNEE | COUNTRY |
|---|---|---|---|
| 1. 2,406,870 | Vacquier | Gulf Research and Development Co. | U.S.A. |
| 2. 2,518,513 | Wyckoff | Gulf Research and Development Co. | U.S.A. |
| 3. 2,555,209 | Vacquier et al | Gulf Research and Development Co. | U.S.A. |
| 4. 2,561,490 | Varian | Varian Associates | U.S.A. |
| 5. 3,070,745 | Serson | Her Majesty the Queen in Right of Canada as Rep. by the Minister of Mines & Technical Surveys | Canada |
| 6. 3,584,292 | Dehmelt | Varian Associates | U.S.A. |
| 7. 3,122,702 | Franken | ---------- | U.S.A. |
| 8. 3,263,161 | Ruddock et al | The Pure Oil Co. | U.S.A. |
| 9. 3,490,032 | Zurfluch | Gulf Research and Development Co. | U.S.A. |
| 10. 3,965,412 | Yungul | Chevron Research Co. | U.S.A. |
| 11. 2,931,974 | McLaughlin et al | Crossland Licensing Corporation Ltd. | U.S.A. |
| 12. 3,829,768 | Nicol et al | The U.S.A. as rep. by the Sec. of the Navy | U.S.A. |
| 13. 1,163,469 | Schlumberger | ---------- | France |
| 14. 1,913,293 | Schlumberger | ---------- | France |
| 15. 2,034,447 | Schlumberger | Compagnie Generale De Geophysique | France |
| 16. 2,284,990 | Schlumberger | ---------- | France |
| 17. 2,586,667 | Kunetz | Compagnie Generale De Geophysique | France |
| 18. 3,188,558 | Yungul | California Research Corp. | U.S.A. |
| 19. 3,188,559 | Yungul | California Research Corp. | U.S.A |
| 20. 2,677,801 | Cagniard | Centre National de la Richerche Scientifique | France |
| 21. 3,514,693 | Cagniard | Centre National de la Richerche Scientifique | France |
| 22. 1,719,786 | Schlumberger | ---------- | France |
| 23. 2,644,130 | Summers | Socony-Vacuum Oil Co. | U.S.A. |
| 24. 2,342,626 | Evjen | Nordel Corp. | U.S.A, |
| 25. 2,347,794 | Piety | Phillips Petroleum Co. | U.S.A. |
| 26. 3,262,050 | Threadgold et al | The British Petroleum Company Ltd. | England |
| 27. 3,068,401 | Janssen | PGAC Development C. | Germany |
| 28. 2,314,597 | Phelan | ---------- | U.S.A. |
| 29. 2,192,404 | Jakosky | ---------- | U.S.A. |
| 30. 2,611,004 | Brant et al | Geophysical Exploration | U.S.A. |
| 31. 3,210,652 | Seigel | ---------- | U.S.A. |

| PATENT NO. | INVENTOR | ASSIGNEE | COUNTRY |
|---|---|---|---|
| 32. 3,745,445 | Seigal | ---------- | Canada |
| 33. 1,678,489 | Sundberg | Aktiebolaget Elektrisk Malmletning | Sweden |
| 34. 1,748,659 | Sundberg | Aktiebolaget Elektrisk Malmletning | Sweden |
| 35. 1,820,953 | Sundberg et al | Aktiebolaget Elektrisk | Sweden |
| 36. 2,929,984 | Puranen et al | Canadian Airborne Geophysics Ltd. | Finland |
| 37. 3,042,857 | Ronka | ---------- | Canada |
| 38. 3,108,220 | Ruddock | Varian Associates | U.S.A. |
| 39. 3,015,060 | McLaughlin et al | Nucom Ltd. | Canada |
| 40. 2,220,070 | Aiken | Schlumberger Well Surveying Corporation | U.S.A. |
| 41. 2,582,314 | Henri-Georges Doll | Schlumberger Well Surveying Corporation | U.S.A. |
| 42. 3,112,443 | Buckner, Jr. | Halliburton Company | U.S.A. |
| 43. 3,555,409 | Atwood et al | Texaco, Inc. | U.S.A. |
| 44. Re. 24,464 | Yost | Socony Mobil Oil Co. Ltd. | U.S.A. |
| 45. 3,105,934 | Barringer | Selco Exploration Co. Ltd. | Canada |
| 46. 2,268,106 | Blau | Standard Oil Development Co. | U.S.A. |
| 47. 4,010,413 | Daniel | Geo-Nav. Inc. | U.S.A. |
| 48. 2,657,380 | Donaldson | ---------- | U.S.A. |
| 49. 3,806,795 | Morey | Geophysical Survey Systems Inc. | U.S.A. |
| 50. 3,286,163 | Holser et al | Chevron Research Co. | U.S.A. |

# NUCLEAR GEOPHYSICAL PROSPECTING *

Nuclear geophysical prospecting can be defined as the utilization of nuclear radiation in studying underground deposits of ores, minerals, oil, gas or water. In its simplest form the variations in the natural radioactivity of the earth is measured and correlated with known standards. This radioactivity occurs primarily from naturally radioactive elements such as; uranium, radium, thorium, and hydrocarbon containing carbon-14 subtances.

There are two main types of nuclear geophysical prospecting; surface, and well or borehole (1,2).** The surface type is carried out by either flying over the area of interest or by physical contact with the surface; that is, by a person walking or riding in a land vehicle with suitable measuring instruments (3,4). In the aerial type of prospecting the variations in the natural radioactivity can be measured directly or atmosphere samples can be periodically or continuously taken and the radioactivity of these samples measured. In the surface contact type, earth samples can be taken and measured (5,6). Such surface type of nuclear geophysical prospecting, however, normally provides only the general location where the substance of interest may be. More precise information about the location of energy resources requires use of the well or borehole technique.

Well or borehole prospecting is often called well or borehole logging because a log or record is made of the geological formations or strata through which the well passes. Borehole nuclear prospecting developed primarily around the continuing search for oil and natural gas (7,8).

Recent problems with the supply and price of energy as well as projected shortages have spurred increased patent activity in both surface and borehole nuclear geophysical prospecting technology. This increased activity is illustrated, by both patent grant date and the application filing date of these patents, in the two graphs on the following page. In the most recent three year period, 1974-76, 116 patents have issued in nuclear geophysical prospecting.

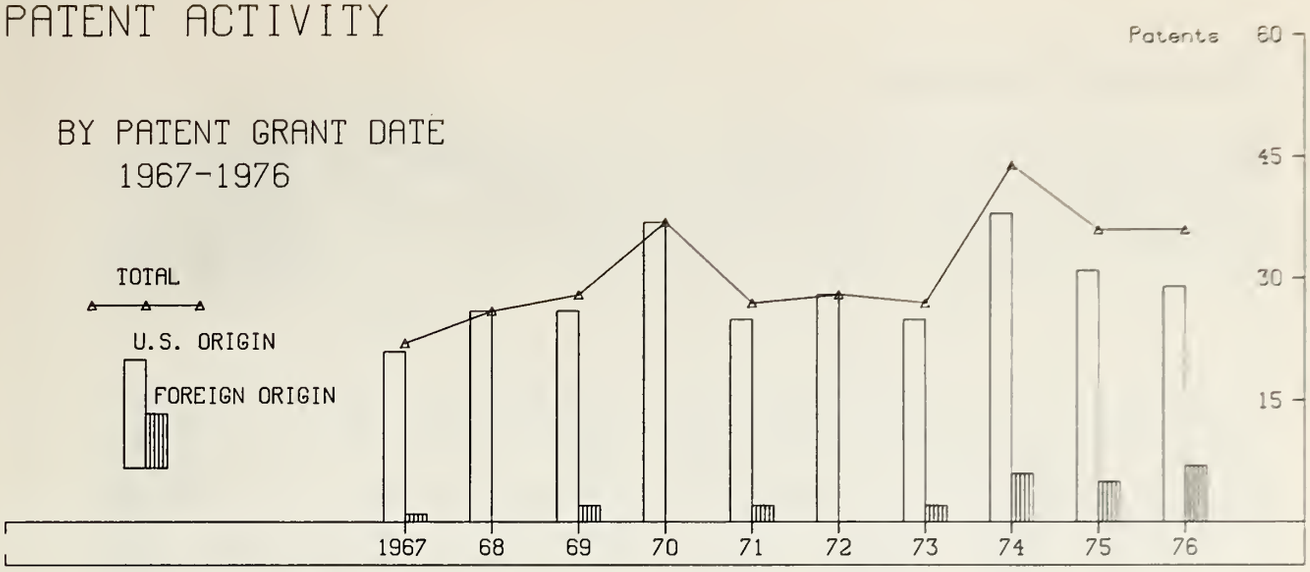
In terms of numbers of patents, the U.S. is the leader in this technology. Over the most recent three year period (1974-76) only 15.5% of all U. S. patents in this area were granted to foreign residents. This is about half the all technology foreign share average of about 35.2% for the same period. The country table which follows the graphs (next page) shows, both by patent grant date and application date, the country distribution of the patents in this field that were granted to foreign residents.

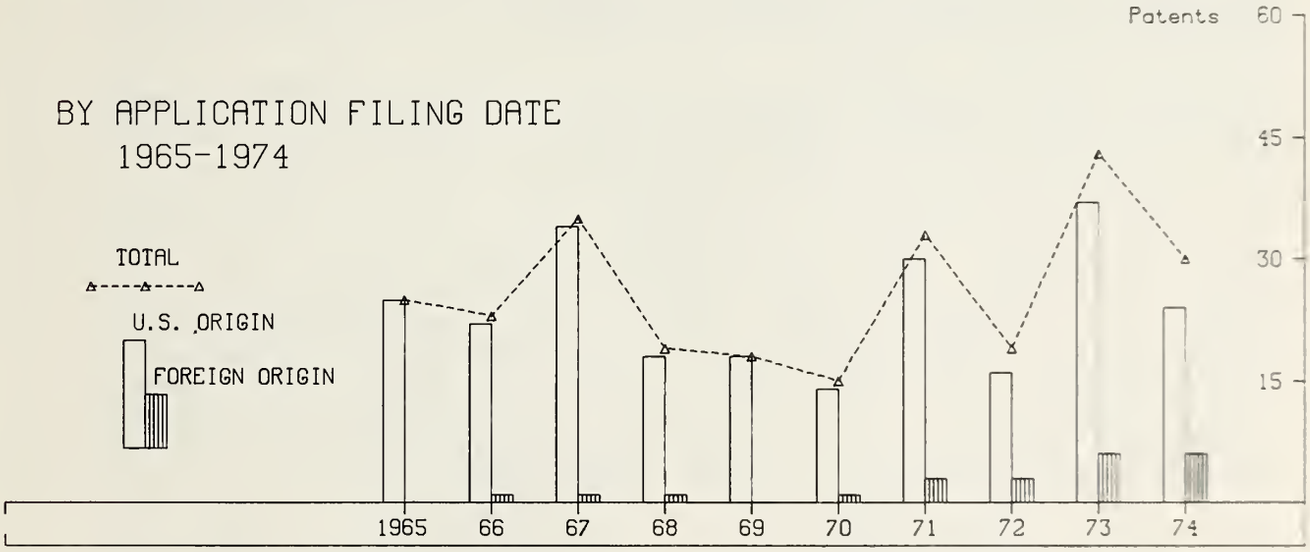
---

* The technology described in this report is contained primarily in U.S. Patent Classification System Class 250, subclasses 253-270.

** Numbers in parentheses refer to patents listed in the Bibliography at the end of this report.

# PATENT ACTIVITY




## DISTRIBUTION OF PATENTS IN AREA OF INTEREST

| | BY PATENT GRANT DATE | | | | | | | | | | TOTAL | BY PATENT APPLICATION FILING DATE | | | | | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1967 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 67-76 | 1965 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 65-74 |
| TOTAL PATENTS | 22 | 26 | 28 | 37 | 27 | 28 | 27 | 44 | 36 | 36 | 311 | 25 | 23 | 35 | 19 | 18 | 15 | 33 | 19 | 43 | 30 | 260 |
| UNITED STATES | 21 | 26 | 26 | 37 | 25 | 28 | 25 | 38 | 31 | 29 | 286 | 25 | 22 | 34 | 18 | 18 | 14 | 30 | 16 | 37 | 24 | 238 |
| TOTAL FOREIGN | 1 | | 2 | | 2 | | 2 | 6 | 5 | 7 | 25 | | 1 | 1 | 1 | | 1 | 3 | 3 | 6 | 6 | 22 |
| FRANCE | | | 1 | | 1 | | | 1 | 2 | 2 | 7 | | 1 | | 1 | | | | | 3 | 2 | 7 |
| AUSTRALIA | | | | | | | 1 | 2 | 1 | | 4 | | | | | | | 2 | 1 | 1 | | 4 |
| UNITED KINGDOM | | | 1 | | | | 1 | | | 1 | 3 | | | | | | | 1 | | | | 1 |
| GERMANY | | | | | 1 | | | | | 3 | 4 | | | 1 | | | | | | | 3 | 4 |
| CANADA | | | | | | | | 1 | 1 | 1 | 3 | | | | | | | | 1 | 1 | 1 | 3 |
| ISRAEL | | | | | | | | | 1 | | 1 | | | | | | | | | 1 | | 1 |
| SWEDEN | | | | | | | | 1 | | | 1 | | | | | | 1 | | | | | 1 |
| SWITZERLAND | | | | | | | | 1 | | | 1 | | | | | | | | 1 | | | 1 |
| ALL OTHER (1) | 1 | | | | | | | | | | 1 | | | | | | | | | | | |

Thrust of the Technology

As recently as 40 years ago the state of oil exploration consisted of drilling oil wells until a recognized oil bearing formation was reached or until the oil under natural pressure gushed out of the well. When oil from this formation or pool was exhausted, the well was either drilled deeper to another possible oil bearing formation or abandoned. Often oil bearing formation , under low pressure but retrievable by pumping, were missed in drilling through to the formation used.

The problem resulted primarily from the inability to electrically log a well, cased for production of the first usable oil pool. Gamma radiation, naturally present, provided a tool for doing this because such radiation will pass through the steel well casing. Thus, a gamma ray measuring instrument, usually a geiger counter, passed through the well can be used to determine where further oil bearing formations may exist (8). This technique is called a natural gamma ray log. When other oil bearing formations are detected in a cased well, the casing is merely perforated by a perforating gun and the oil is removed (8, 9).

The main problem with natural gamma ray logging is that often false indications are obtained, that is, gamma ray patterns may indicate an oil formation situated behind a well casing when none exists.

A technique was developed to supplement, and, in some cases, replace gamma ray logging which uses externally applied radiation other than natural radiation. When gamma rays from a source such as, radium, cobalt-60, or cesium-137, are directed onto a specific substance, the gamma radiation will penetrate and backscatter from that substance in direct relation to its density. This indication of density can be used to locate oil deposits (10, 11). This technique is known as gamma-gamma logging and usually involves passing an instrument containing a gamma ray source and a gamma ray detector through a well.

While an improvement, gamma-gamma logging is not entirely satisfactory since some non-oil-bearing formations will give a density reading similar to an oil-bearing formation.

This led to the development of a more direct method of identifying an oil bearing formation, neutron-gamma logging. When fast neutrons are directed into a substance containing hydrogen, the resulting collision or reaction between the neutrons and the hydrogen atoms produces secondary gamma rays. This type of well logging uses an instrument similar to the gamma-gamma type except that a neutron source, typically radium -beryllium, replaced the gamma source (12, 13, 14). In this type of source the alpha particles emitted by the radium, react with the beryllium target material producing fast neutrons.

It was also known that fast neutrons would react with hydrogen containing material and would be partially absorbed or slowed down. This reaction produces slow or thermal neutrons. If the gamma detector were replaced by a neutron detector, these thermal neutrons indicative of hydrogen could

be detected. This type of logging is called neutron-neutron (15, 16, 17).

The limitation of both neutron-gamma and neutron-neutron logging, in the early stages, was that some of the hydrogen containing formations identified did not contain oil. Water for example, gave essentially the same response as oil.

The solution to this problem was the development of better radiation detectors. The early radiation detector, used in the nuclear logging sondes or probes approximately 30 to 40 years ago, was a gas-filled, ionization chamber, often called a Geiger-Mueller detector. This type of detector will give a reading as to intensity or frequency of radiation present but can not accurately define the magnitude or amplitude of the signal current generated. With the development of the scintillation detector, pulse height definition of the output current of the detector was made possible (18, 19). A scintillation detector is composed of a phosphor material or crystal that produces a pulse or flash of light when a gamma ray or a particle, such as, alpha, beta or neutron, strikes and reacts with it. This phosphor is placed adjacent the photocathode portion of a photomultiplier tube so that light generated in the phosphor is picked up by the photomultiplier. The output current of the photomultiplier is indicative of the amount and amplitude of the light generated in the phosphor material.

With the use in neutron-gamma and neutron-neutron logging of the scintillation detector which distinguished energy levels of induced secondary radiation, it was found that each element of the periodic table emitted induced radiation at a single distinct energy level or at a plurality of distinct energy levels (20, 21, 22). Thus with a scintillation detector, as depicted in Figure 1, it was possible to identify specific elements present in the various borehole strata. Fine distinctions were possible. For example, the presence of salt water instead of fresh water could be determined by means of the induced gamma rays produced when neutrons react with chlorine(23, 24). This is important because salt water is always present in or near oil pools or formations. Also distinctive energy peaks are produced by neutrons reacting with carbon, a major component of oil (22).

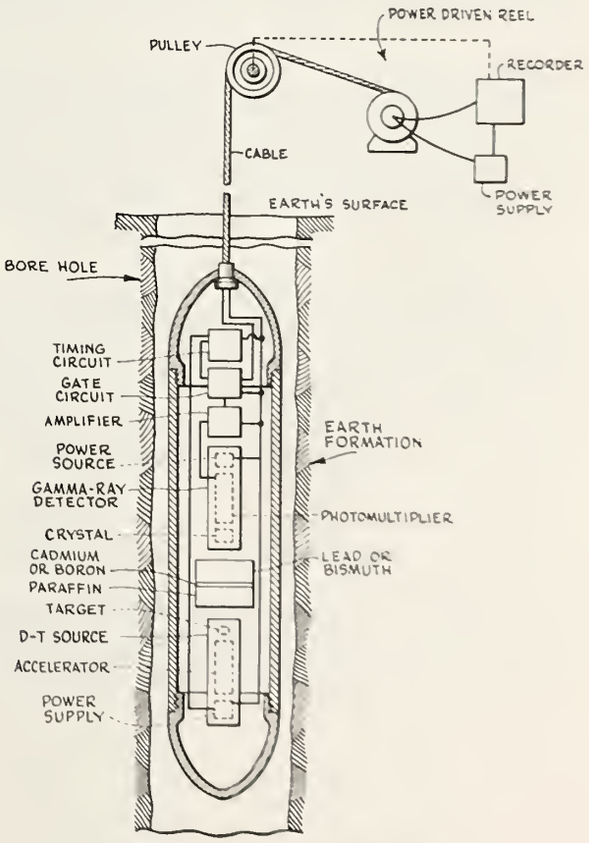



FIG. 1: NUCLEAR SCINTILLATION WELLHOLE LOGGING

Further improvements have also been made in the neutron source. Neutron sources first used were of what is usually called the chemical type, such as, radium-beryllium or polonium-berryllium. The high-energy alpha particles emitted by the radium or polonium react with the beryllium atoms, producing neutrons having a plurality of energy levels. For example, a radium-berryllium source produces neutrons in the range of from 2 to 11 m.e.v. (25). A mono-energetic source of neutrons and of higher energy level was often desireable in borehole logging. While it was known that mono-energetic neutrons of 14 m.e.v. could be produced when deuterium ions are accelerated at high velocities and directed at a target containing tritium ions, it took a number of years to develop such a neutron source that could be placed in a well logging sonde, the maximum diameter of which is usually about 5 inches (26, 27).

Most of these chemical or accelerator type neutron sources operated continuously which at times precluded accurate detector results because of source and borehole effects. Hence source pulsing of the source was developed which permitted the source to be turned on and off for specified periods of time. In the chemical type of neutron source this is usually accomplished by a shutter, normally a rotary type, that passes between the alpha emitter and the target material (28, 29). In the accelerator type of neutron source the pulsing is accomplished by a trigger or switching circuit, which simply turns the accelerator on and off at a very rapid rate. For chemical sources that are pulsed, neutron pulse lengths as short as 1 millisecond down to several hundred microseconds are possible (30). For the accelerator type of neutron source, neutron pulse lengths shorter than one microsecond can be produced (31).

Another advancement was the use of a pulsed detector in combination with a pulsed source. This technique substantially eliminates source and borehole fluid effects in the detected results by leaving the detector off during the period when the source is on and for a predetermined period after the source is off (32). The use of a plurality of detection periods between the pulses was also developed (33).

In surface prospecting by means of a vehicle in contact with the earth's surface the following types of logging can be used, in addition to a natural gamma log: gamma-gamma for density of the substances near the surface (34); neutron-gamma for specific identification of elements present at or near the surface (35), and, neutron-neutron for moisture content of the soil at or adjacent the surface (36).

In the borehole, the neutron-neutron log can be used to determine the fluid content of a formation and therefore its porosity (37, 38).

Normally in nuclear geophysical prospecting, a plurality of logs, often natural gamma, gamma-gamma, neutron-neutron and neutron-gamma, are made simultaneously (39, 40, 41).

Radioactive tracers have also been applied to borehole logging. Porosity or density can be determined by shooting a radioactive bullet into a formation and detecting the degree of penetration by the strength of radiation detected (42, 43). Also, radioactive fluid can be injected, subsequently removed and residual radiation detected (44, 45).

The movement of fluids in a borehole can be determined by injecting a radioactive fluid and a non-radioactive fluid simultaneously at substantially the same or varying pressures, with a detector following the movement of the interface between the two (46, 47).

Future Trends

The major advances in nuclear borehole prospecting have been the development of the scintillation detector (18, 19); the accelerator type, monoenergetic neutron source (26, 27); and the pulsing of source and detector for specific periods (32, 33).

The thrust of the technology at present appears to be in further refinement of systems utilizing pulsed sources and detectors, and the correlation of a plurality of simultaneous logs from these systems by data processing type circuitry (48, 49, 50).

Technology Analysis by
Archie Borchelt
Patent Examiner

# BIBLIOGRAPHY


| | PATENT NO. | INVENTOR | ASSIGNEE | COUNTRY |
|---|---|---|---|---|
| 1. | 2,904,691 | Mulligan | Texaco Inc. | U.S.A. |
| 2. | 2,219,273 | Scherbatskoy | Well Surveys, Inc. | U.S.A. |
| 3. | 2,781,453 | Belcher et al | Cornell University | U.S.A. |
| 4. | 3,341,706 | Swift et al | Dresser Industries, Inc. | U.S.A. |
| 5. | 2,562,961 | Stratford et al | The Texas Company | U.S.A. |
| 6. | 3,609,363 | Milly | Geomet Mining and Exploration Co. | U.S.A. |
| 7. | 2,390,433 | Fearon | Well Surveys, Inc. | U.S.A. |
| 8. | 2,197,453 | Hassler | Shell Development Co. | U.S.A. |
| 9. | 2,957,083 | Scherbatskoy | PGAC Development Co. | U.S.A. |
| 10. | 2,365,763 | Kalb et al | Said Kalb | U.S.A. |
| 11. | 2,934,652 | Caldwell et al | Socony Mobil Oil Co., Ltd. | U.S.A. |
| 12. | 2,349,712 | Fearon | Well Surveys, Inc. | U.S.A. |
| 13. | 2,515,500 | Fearon et al | Well Surveys, Inc. | U.S.A. |
| 14. | 3,294,972 | Youmans | Dresser Industries Inc. | U.S.A. |
| 15. | 2,508,772 | Pontecorvo | Well Surveys, Inc. | Canada |
| 16. | 2,933,609 | Norelius | Dresser Industries Inc. | Venezuela |
| 17. | 3,200,251 | Youmans | Well Surveys, Inc. | U.S.A. |
| 18. | RE 24,226 | Fearon | Well Survesy, Inc. | U.S.A. |
| 19. | RE 24,797 | Scherbatskoy | PGAC Development Co. | U.S.A. |
| 20. | 3,184,598 | Tittle | Schlumberger Ltd. (Schlumberger N.V.) | U.S.A. |
| 21. | 3,452,201 | Hall, Jr. | Texaco, Inc. | U.S.A. |
| 22. | 3,780,301 | Smith Jr. et al | Texaco, Inc. | U.S.A. |
| 23. | 2,862,106 | Scherbatskoy | ---------- | U.S.A. |
| 24. | 2,219,821 | McKay et al | Texaco Inc. | U.S.A. |
| 25. | 2,948,811 | Bonner et al | Socony Mobil Oil Co., Ltd. | U.S.A. |
| 26. | 2,884,534 | Fearon et al | Well Surveys, Inc. | U.S.A. |
| 27. | 3,461,291 | Goodman | Schlumberger Technology Corp. | U.S.A. |
| 28. | 2,275,748 | Fearon | Well Surveys Inc. | U.S.A. |
| 29. | 3,389,257 | Caldwell et al | Mobil Oil Corp. | U.S.A. |
| 30. | 3,885,160 | Dillingham | The Western Co. of North America | U.S.A. |
| 31. | 2,867,728 | Pollock | Gen. Electric Co. | U.S.A. |
| 32. | 3,379,884 | Youmans | Dresser Industries Inc. | U.S.A. |
| 33. | 2,991,364 | Goodman | Schlumberger Well Surveying Corp. | U.S.A. |
| 34. | 3,846,631 | Kehler | Applied Invention Corporation | U.S.A. |
| 35. | 3,463,922 | Senftle et al | U.S.A. as Rep. by the Sec. of Interior | U.S.A. |

-BIBLIOGRAPHY CONTINUED-


| PATENT NO. | INVENTOR | ASSIGNEE | COUNTRY |
|---|---|---|---|
| 36. 3,428,806 | Wack | Electricite De France (Service National) | France |
| 37. 3,546,454 | Schuster | Schlumberger Ltd. | U.S.A. |
| 38. 4,005,290 | Allen | Mobil Oil Corp. | U.S.A. |
| 39. 2,761,977 | McKay | The Texas Co. | U.S.A. |
| 40. 3,691,378 | Hopkinson et al | Dresser Industries Inc. | U.S.A. |
| 41. 3,823,319 | Tittman | Schlumberger Technology Corp. | U.S.A. |
| 42. 2,320,643 | Neufeld | Well Surveys Inc. | U.S.A. |
| 43. 2,685,038 | Hoss | ---------- | U.S.A. |
| 44. 2,352,993 | Albertson | Shell Development Co. | U.S.A. |
| 45. 2,733,353 | Pirson | Stanolind Oil and Gas Co. | U.S.A. |
| 46. 2,700,734 | Egan et al | The Texas Co. | U.S.A. |
| 47. 3,100,258 | Ten Brink et al | Texaco Inc. | U.S.A. |
| 48. 3,609,366 | Schwartz | Schlumberger Technology Corp. | U.S.A. |
| 49. 3,890,501 | Johnstone | Schlumberger Technology Corp. | U.S.A. |
| 50. 3,979,300 | Paap et al | Texaco Inc. | U.S.A. |

## GRAVITATIONAL FIELD MEASUREMENT

Processes and apparatus for determining the force of gravity by direct measurement, comparison to other gravitational measurements, or by determining acceleration differentials caused by gravity. The gravitation measuring systems found here are directed to geophysical exploration for hydrocarbons, prospecting for minerals and water, inertial guidance systems and sea level contour measurements. (Class 73, subclasses 382 R and 382 G).

Activity Indices (1974-1976)

| | | | |
|---|---|---|---|
| Growth (10 year base) | 13.0% | Corporate Owned | 44.4% |
| Foreign Growth | 11.1% | Government Owned | 22.2% |

Recent Activity

Recent patent activity has been directed towards devices which measure gravitational fields by electrical measurement of relative differences in the acceleration of a plurality of masses. Particular emphasis has been placed on gravitometers capable of fine scale field measurement from high flying aircraft or earth satellites. Patents issued since February 1975 include:

4,023,413 - Device For Measuring Accelerations, Particularly Accelerations Due to Gravity (Stauber, Wyler AG) - Discloses a system for measuring components of acceleration due to gravity. A disc shaped deflector is mounted between two stator electrodes and adopted to move so as to vary its spacing between the electrodes. This movement produces a direction dependent electrical signal which is proportional to the amount of deflector displacement. It is asserted that this measuring device is largely insensitive to oscillations, shocks and temperature variations and, concomitantly, is highly accurate when operating under adverse measuring conditions.

4,022,064 - Gravity And Velocity-Change Differentiator (Preston) - Discloses a portable gravitometer which electrically measures the differences in gravity intensity at different places on the earth's surface, useful for the detection of both, minerals of differing densities and water, which are beneath the surface of the earth. A generator is powered by an electric motor in such a way that the torque of the electric motor reacting against its stator assembly, and the action of the stator of the generator, resisting the magnetic force of its rotor indicates differences in acceleration of gravity by the changes in the amount of current necessary for the motor-generator circuit.

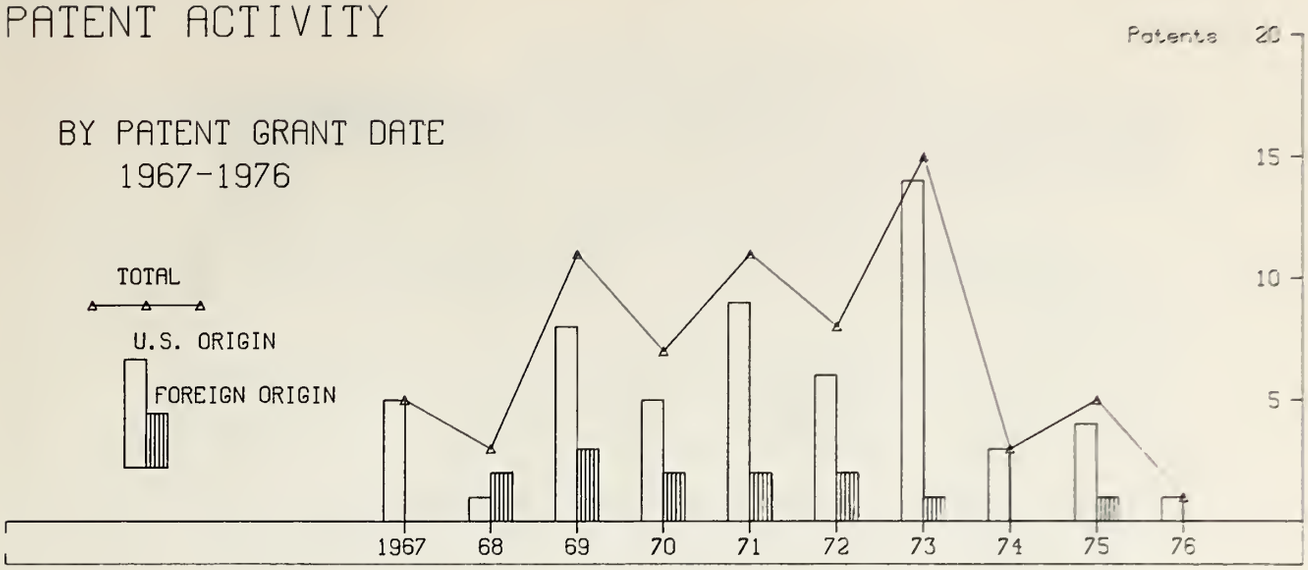
3,991,625 - Gravity-Measuring Device For Water And Mineral Detection (Preston) - Discloses the measurement of gravity by a motor-generator system whose moving parts are interconnected by a torque transmitter. The torque of the electric motor and the resistance of the electric generator lift either the motor or the generator against the force of gravity. The lift distance is determined by a mercury switch which is horizontal to the ground when the housing of the generator is in a plane horizontal with that of the electric motor. Differences in gravity are measured by reading differences in both motor and generator ammeters.

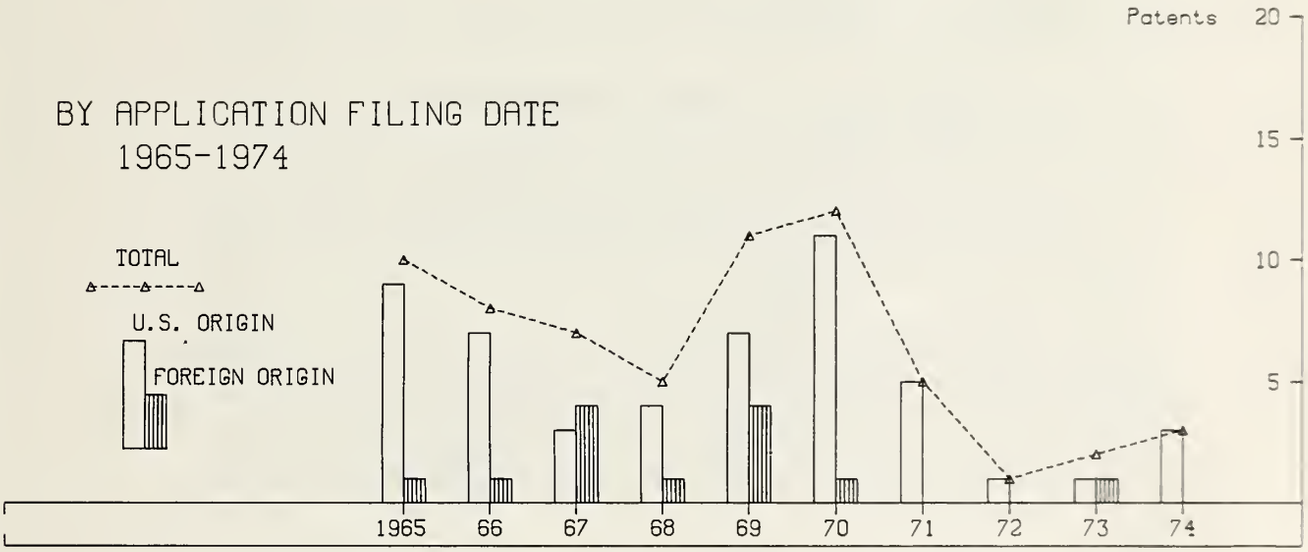
3,926,054 - Gravity Gradiometer (Buck, The Charles Stark Draper Laboratory, Inc.) - Discloses a continuously measuring vertical gravity gradient gradiometer, for use in boreholes. Two dynamically balanced pendulums (DBP's) are configured with their respective sensitive axes parallel to a common gradiometer sensitive axis. The DBP's each include a pendulous integrating gyro, the gyros being separated by a predetermined distance along the gradiometer's sensitive axis. When the sensitive axis is vertically aligned the torque-to-null is directly proportional to the vertical gravity gradient along the length of the sensor coupling shaft.

3,888,122 - Method And Apparatus For Obtaining The Fine Scale Structure of The Earth's Gravity Field (Black, The United States of America as represented by the Secretary of the Navy) - Discloses a method and apparatus for determining the direction of the along-track and across-track components of the local gravitational force vector over the surface of an ocean. Two identical satellites are placed in coincidental orbits and are spatially separated in the orbital plane by a temporal interval. The height of each satellite above mean sea level is measured by radar altimeters as each satellite passes through a given point in inertial space and the difference in height between the satellites determined. Computing the differences in altimeter readings of the two satellites at a given point in inertial space provides the across-orbit component of the local gravitational force vector. The along track component is obtainable through direct readings.

3,865,467 - Retroreflecting Beam Splitter And Apparatus For Measuring Gravity Gradients Embodying The Same (Von Thuna, Arthur D. Little, Inc.) - Discloses a method and apparatus for optically determining gravity gradients which are used to detect ore bodies and oil reserves beneath the surfact of the earth. Two in line retroreflectors are placed in free flight under gravity and are irradiated by coherent monochromatic light beams. The retroreflectors cause interference between the light beams and a detector measures the temporal variations of intensity of the interfering reflected light. The time rate of change of the angular frequency of this signal is directly related to and provides for the vertical gradient of gravity.

# PATENT ACTIVITY




## DISTRIBUTION OF PATENTS IN AREA OF INTEREST

| | BY PATENT GRANT DATE | | | | | | | | | | TOTAL | BY PATENT APPLICATION FILING DATE | | | | | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1967 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 67-76 | 1965 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 65-74 |
| TOTAL PATENTS | 5 | 3 | 11 | 7 | 11 | 8 | 15 | 3 | 5 | 1 | 69 | 10 | 8 | 7 | 5 | 11 | 12 | 5 | 1 | 2 | 3 | 64 |
| UNITED STATES | 5 | 1 | 8 | 5 | 9 | 6 | 14 | 3 | 4 | 1 | 56 | 9 | 7 | 3 | 4 | 7 | 11 | 5 | 1 | 1 | 3 | 51 |
| TOTAL FOREIGN | | 2 | 3 | 2 | 2 | 2 | 1 | | 1 | | 13 | 1 | 1 | 4 | 1 | 4 | 1 | | | 1 | | 13 |
| GERMANY | | 2 | 2 | | | 1 | 1 | | | | 6 | 1 | | 3 | | 1 | 1 | | | | | 6 |
| FRANCE | | | 1 | | 1 | 1 | | | | | 3 | | | | 1 | 2 | | | | | | 3 |
| U.S.S.R. | | | | 2 | | | | | | | 2 | | 1 | 1 | | | | | | | | 2 |
| NORWAY | | | | | 1 | | | | | | 1 | | | | | 1 | | | | | | 1 |
| UNITED KINGDOM | | | | | | | | | 1 | | 1 | | | | | | | | | 1 | | 1 |

## OFFSHORE SEISMIC PROSPECTING

Signal communication systems and apparatus in which the signal is carried underwater by compressional waves and is utilized for geophysical exploration. Seismic data receiving and processing systems which are particularly adopted for offshore use are found here. (Class 340, subclass 7R).

Activity Indices (1974-1976)

| | | | |
|---|---|---|---|
| Growth (10 year base) | 26.1% | Corporate Owned | 83.7% |
| Foreign Share | 10.2% | Government Owned | 14.3% |

Recent Activity

Recent patent activity has focused on hydrophone receiver array configurations which reduce noise and act as bandwidth filters. Activity has also been directed to determining hydrophone cable position relative to the towing boat and earth reference points by satellite communication or by the forces exerted by the towed cable on sensors connected to the towing boat. Patents issued since February 1976 include:

4,020,447 - Method And Apparatus For Recording Seismic Signals (Michon et al, Compagnie Generale de Geophysique) - Discloses an offshore seismic prospecting system utilizing a long cable with a large number of detectors spaced relatively far apart (e. g., 48 detectors, 50 meters apart) and a short cable with a small number of detectors placed relatively close to each other (e.g., 6 detectors, 25 meters apart). The electrical signals produced by the detectors of both cables in response to received seismic waves are successively recorded in common, without commutation, and are distinguishable as a result of relative amplitude and time separation.

4,011,540 - Combined Electret Hydrophone And Transmission Line (Farr, Standard Oil Company (Indiana) )- Discloses a continuous line hydrophone streamer with multiple co-axial transmission cable segments each containing two concentric conductors and an electret spacer between the conductors. A voltage controlled oscillator is coupled to the first of the cable segments to generate a carrier wave signal. Seismic waves which impinge upon the electret-transducer segments generate a voltage change in the conductors and modulate the carrier wave. The carrier waves from the first transmission segment are transmitted to the next successive segment so that seismic signals from the most instant cable segment are coupled through the entire length of the streamer to a recording system.

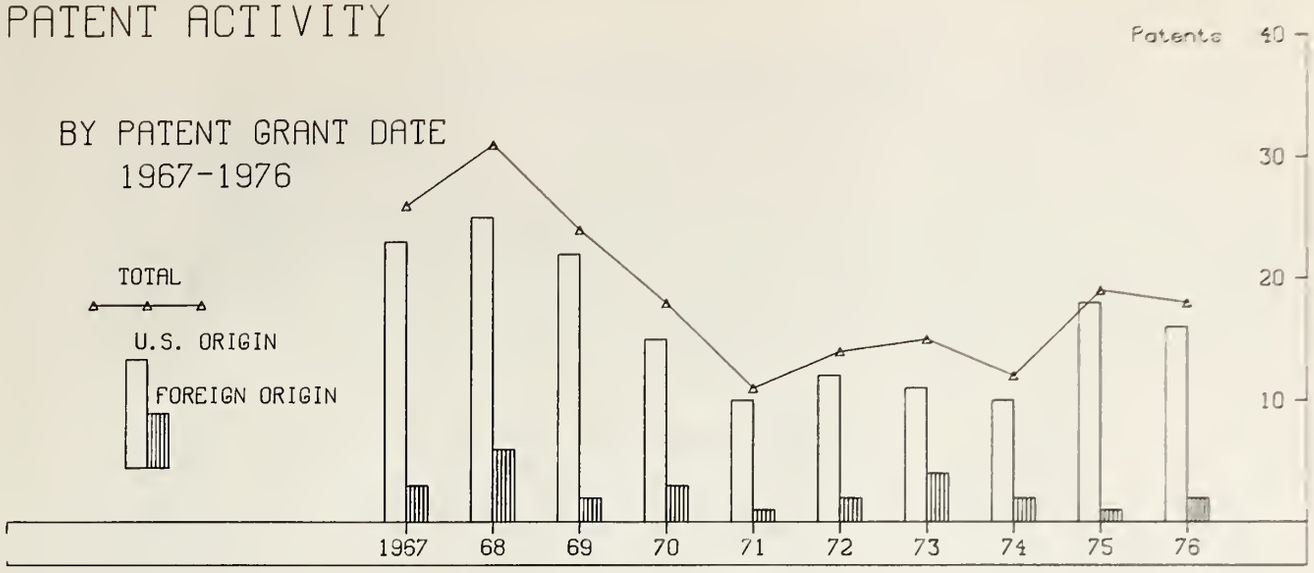
4,011,539 - Seismic Detector Arrays (Rogers, Texaco Inc.) - Discloses a hydrophone cable having an array of detector groups towed behind a marine seismic vessel. The detector groups are separately spaced along the length of the array and each detector group has a plurality of hydrophones spaced so as to conform to a Gaussian frequency distribution. The detector spacing operates to truncate the frequency passband at frequency limits according to the degree of noise suppression, or array response level required. The responses of each detector group along the cable are processed and analyzed to determine the likelihood of the existance of hydrocarbon reserves in the submerged formations.

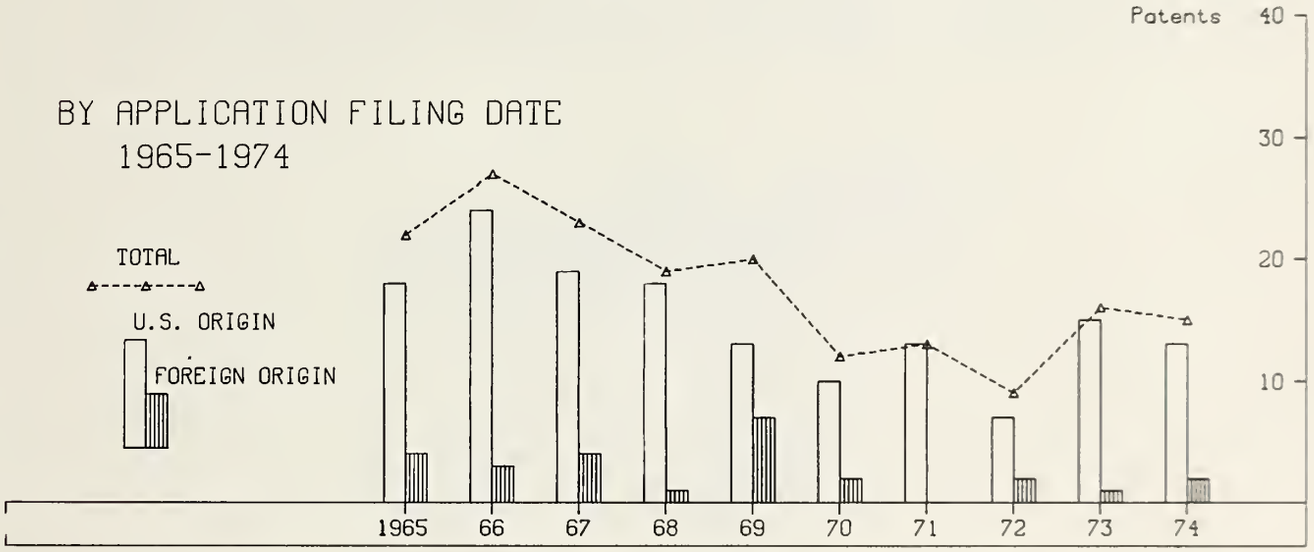
3,978,446 - Electret Cable Hydrophone Array (Miller, GTE Sylvania Incorporated) - Discloses a hydrophone array for marine seismic exploration having a longitudinal series of electrically separate sensor sections. The sensor sections have radially spaced co-axial inner and outer conductors and longitudinally extending electret cables in the annular space between the conductors. Each cable has a conductive lead wire insulated by an electret covering, such as tetrafluroethylene, which has been electrostatically charged. An outer jacket of neoprene covers the outer conductor and seals the cable.

3,953,827 - Method Of Determining The Angular Position Of A Towed Marine Seismic Cable And Apparatus For Carrying Out Said Method (Le Moal et al, Entreprise de Recherches et d' Activities Petrolieres (E. R. A. P. )) - Discloses a method of determining the position of a plurality of hydrophones on a towed seismic marine cable by interpolating values obtained by measuring the angle between the tangent to the attachment point of the towed cable and a fixed and known direction. A potentiometric magnetic compass is used for the angle measurement; a hydrophone is used to measure the distance between the seismic wave generator and the compass; and a potentiometric manometer measures the depth of the compass. The hydrophone cable position data is used to indicate which seismic data pertains to a particular subsurface area.

3,952,281 - Method Of Marine Reflection - Type Seismic Exploration (Parrack, Texaco Inc.) - Discloses a method of marine reflection seismic surveying using a dual spread of hydrophones which are vertically spaced apart. The signals produced by the uppermost hydrophones, in response to an upgoing reflected seismic wave are delayed so that downgoing acoustic wave signals are in time coincidence with downgoing seismic wave signals from the lower hydrophones. The signals produced by both hydrophone spreads are then algebraically combined so as to cancel the undesired downgoing reflected wave signals.

# PATENT ACTIVITY




## DISTRIBUTION OF PATENTS IN AREA OF INTEREST

| | BY PATENT GRANT DATE | | | | | | | | | | TOTAL | BY PATENT APPLICATION FILING DATE | | | | | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1967 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 67-76 | 1965 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 65-74 |
| TOTAL PATENTS | 26 | 31 | 24 | 18 | 11 | 14 | 15 | 12 | 19 | 18 | 188 | 22 | 27 | 23 | 19 | 20 | 12 | 13 | 9 | 16 | 15 | 176 |
| UNITED STATES | 23 | 25 | 22 | 15 | 10 | 12 | 11 | 10 | 18 | 16 | 162 | 18 | 24 | 19 | 18 | 13 | 10 | 13 | 7 | 15 | 13 | 150 |
| TOTAL FOREIGN | 3 | 6 | 2 | 3 | 1 | 2 | 4 | 2 | 1 | 2 | 26 | 4 | 3 | 4 | 1 | 7 | 2 | | 2 | 1 | 2 | 26 |
| FRANCE | 1 | 4 | | 2 | | | 4 | 2 | | 2 | 15 | 3 | 2 | | | 4 | 1 | | 2 | 1 | 2 | 15 |
| UNITED KINGDOM | 1 | | 1 | 1 | 1 | 1 | | | 1 | | 6 | 1 | | 1 | 1 | 3 | | | | | | 6 |
| GERMANY | 1 | | | | | | | | | | 1 | | | 1 | | | | | | | | 1 |
| CANADA | | 1 | | | | 1 | | | | | 2 | | 1 | | | | 1 | | | | | 2 |
| NETHERLANDS | | | 1 | | | | | | | | 1 | | | 1 | | | | | | | | 1 |
| U.S.S.R. | | 1 | | | | | | | | | 1 | | | 1 | | | | | | | | 1 |

# SEISMIC SIGNAL PROCESSING*

## Introduction

To locate and extract deposits of oil and gas in the outer layers of the earth's crust, a profile of the subsurface strata is necessary. To provide this profile the subsurface can be irradiated with acoustic waves, a portion of which, after reflection and/or refraction, can be detected at the earth's surface. The processing of the detected waves in order to facilitate interpretation of the signal information is defined as seismic signal processing.

The basic theory of seismic reflection prospecting and signal processing is depicted in Figure 1. A seismic source (e.g. dynamite, air gun, vibrator, or weight drop) creates elastic disturbances which propagate through the earth. A very small portion of the downwardly traveling elastic waves is reflected up from each interface between layers of differing hardness and density. The deeper the layer is in the earth, the longer it takes for a signal reflected from that layer to arrive at the surface and be detected by an array of geophones (surface receivers).**

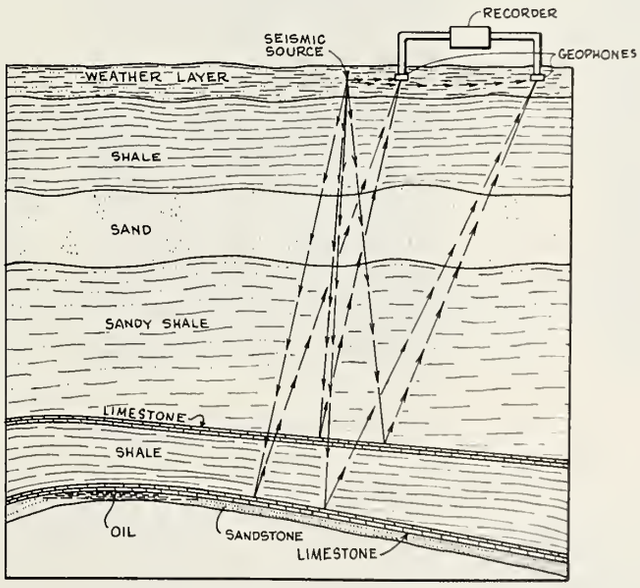



*FIG. 1: SEISMIC REFLECTION PROSPECTING*

---

* Patents considered in this report are mainly classified in Classes 340, sub-classes 15.5 R-VD, although selected patents from Class 340, subclass 7, Class 181 and Class 444 were also used. A complete patent listing is available on request from the Office of Technology Assessment and Forecast, U. S. Patent and Trademark Office, Washington, D. C. 20231.

**These arrays typically contain up to 100 geophones laid out in patterns and are connected by a seismic master cable which ranges from 1 to 3 miles in length.

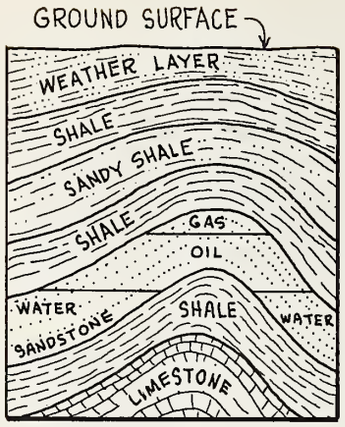



*FIG. 2 a.*
*ANTICLINAL TRAP*

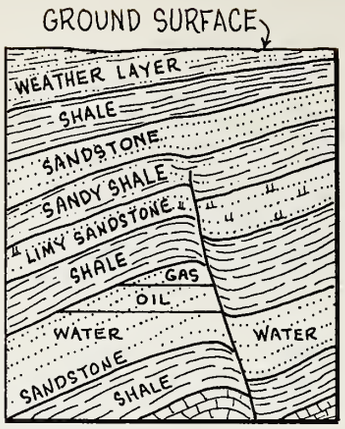



*FIG. 2 b.*
*FAULT TRAP*

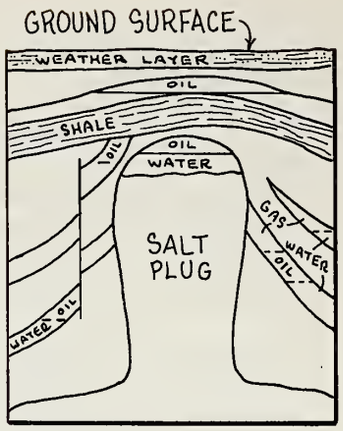



*FIG. 2 c.*
*SALT DOME*

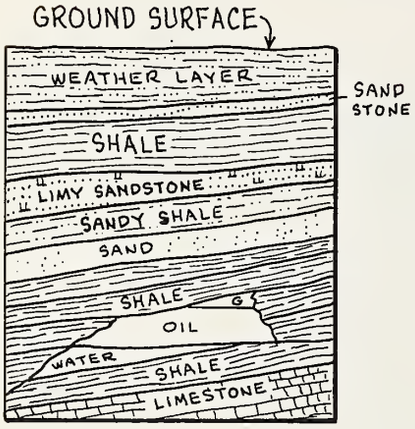



*FIG. 2 d.*
*REEF TRAP*

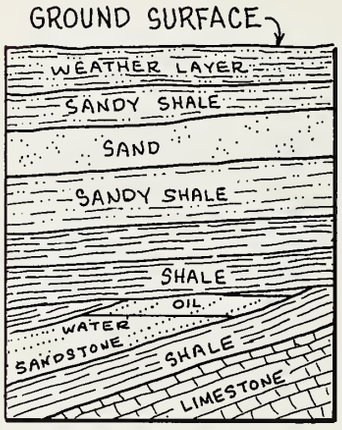


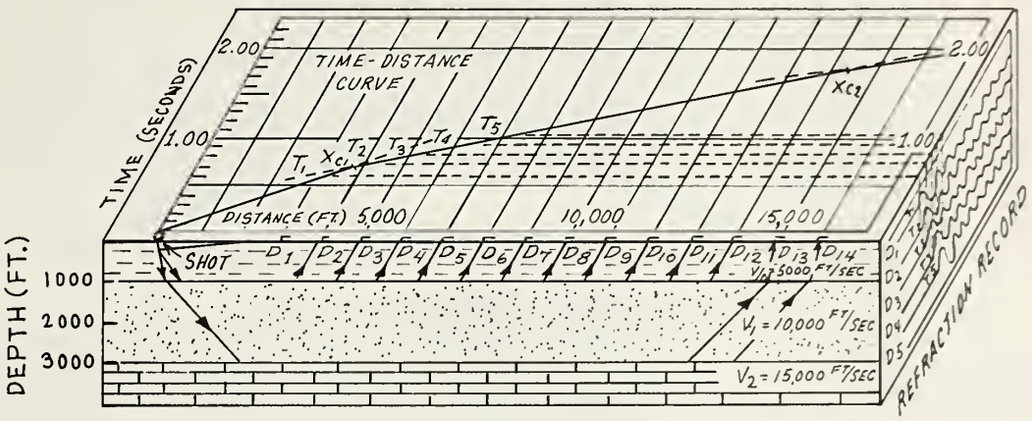

*FIG. 2 e.*
*STRATIGRAPHIC TRAP*

(These Figures Based Upon Drawings From "Seismic Prospecting For Oil", C. Hewitt Dix, Harper & Row)

The arrival times of primary reflections (single bounce echoes) at the geophone array permit the determination of depth and inclination angles of the subsurface reflectors when subsurface velocities are known. The lithological characteristics can be determined from the reflection amplitudes and attenuation characteristics contained in the reflected signals. This method makes it possible to detect and map structural features which are associated with accumulations of gas and oil, such as anticlines (Fig. 2a; convex upward structures), faults (Fig. 2b; linear displacement), salt domes (Fig. 2c), reefs (Fig. 2d), and stratigraphic traps (Fig. 2e; lateral changes in composition).

Where seismic waves are primarily refracted by the subsurface strata, another mode of geophysical prospecting can be pursued. This method depends on the subsurface layers having relative acoustic velocities greater than that of the contiguous overlying strata in order to diffract the seismic waves. Massive limestones, hard sandstones, salt formations, igneous rocks or basement are the most common subterranean refractors.

Figure 3 (below) shows the time-distance-depth relations for a refraction profile over two subsurface discontinuities and depicts the actual path taken by the refracted wave as the minimum time path. The arrival times for the first five detector positions are measured on the record shown schematically at the right side of the block. The three segments of the time-distance curve represent paths along the tops of the respective layers. The two breaks in the slope of the time-distance curve occur at the cross-over distances $Xc_1$ and $Xc_2$ for the respective interfaces.




## FIG. 3: SEISMIC REFRACTION PROSPECTING MODEL

(FIG 3: Seismic Refraction Prospecting Model is from "Introduction To Geophysical Prospecting" By Milton B. Dobrin, copyright 1976 by McGraw-Hill, Inc. Used with Permission of McGraw-Hill Book Company)

The depth of the refracting layers and the speed of sound in the layers are determined from the times required for the refracted wave to travel between the source and the receivers. The refraction method of seismic prospecting is used primarily to determine, in newly explored areas, the existence of high acoustic velocity layers, their depths, and their slopes with respect to the earth's surface.

Seismic signal processing facilitates the interpretation of the received signals and mitigates the effects of signal noise. Figure 4 (next page) depicts a cross section of the earth's crust and illustrates the various types of noise which are induced by strata being explored.

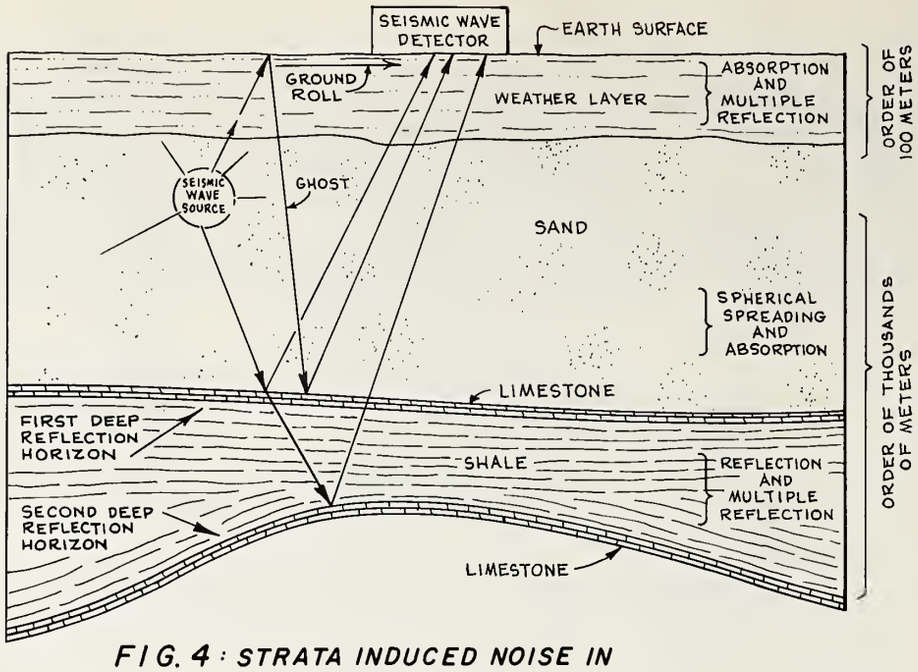



*FIG. 4: STRATA INDUCED NOISE IN SEISMIC PROSPECTING*

Since the first use of reflection seismography to discover oil, 50 years ago (1)*, the extraction of fossil fuels from the earth has continued at an increasing rate. Furthermore, the areas where the determination of the presence of gas and oil are easily ascertained has greatly diminished. Concomitantly, research, development, and patenting in the area of seismic prospecting and signal processing have grown significantly.

In the most recent three year period, 1974-1976, 168 patents have issued in this area. This is 22.5% of all patenting in this technology in the last decade. The first two graphs on the following page illustrate this growth, first by patent grant date and then by application date of these patents.

The foreign activity in seismic signal processing for the period 1974-76 is 16.1%, less than half the all technology foreign share average of 35.2%. The country table which follows the graphs shows, by patent grant date and patent application date, the country distribution of the patents in this field that were granted to foreign residents.

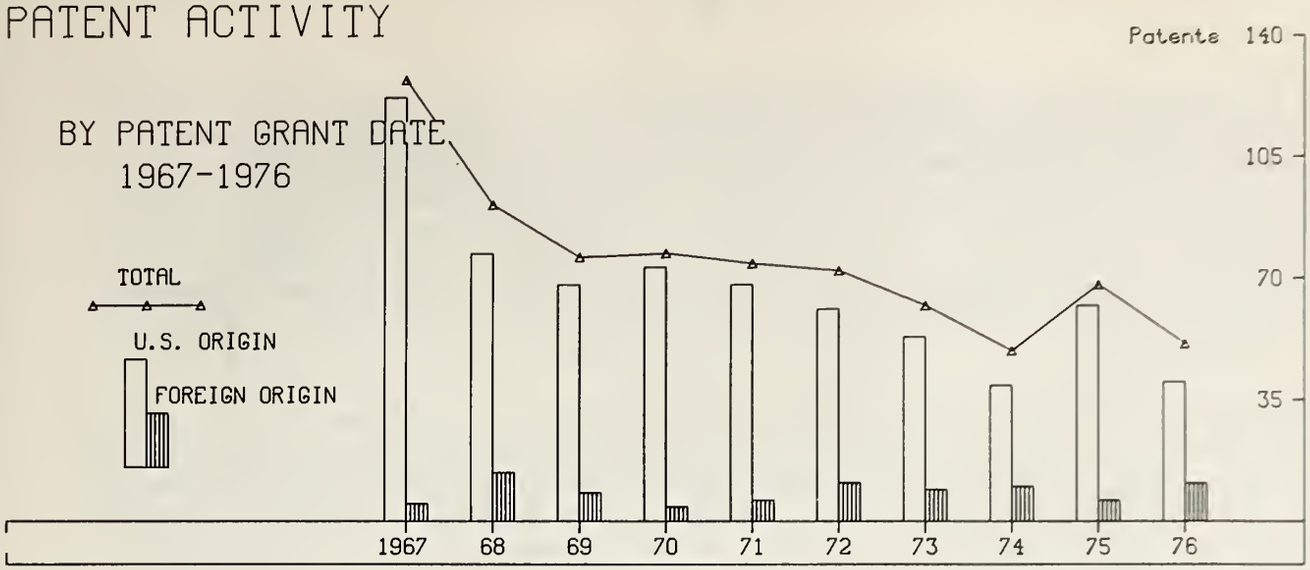
Development of The Technology

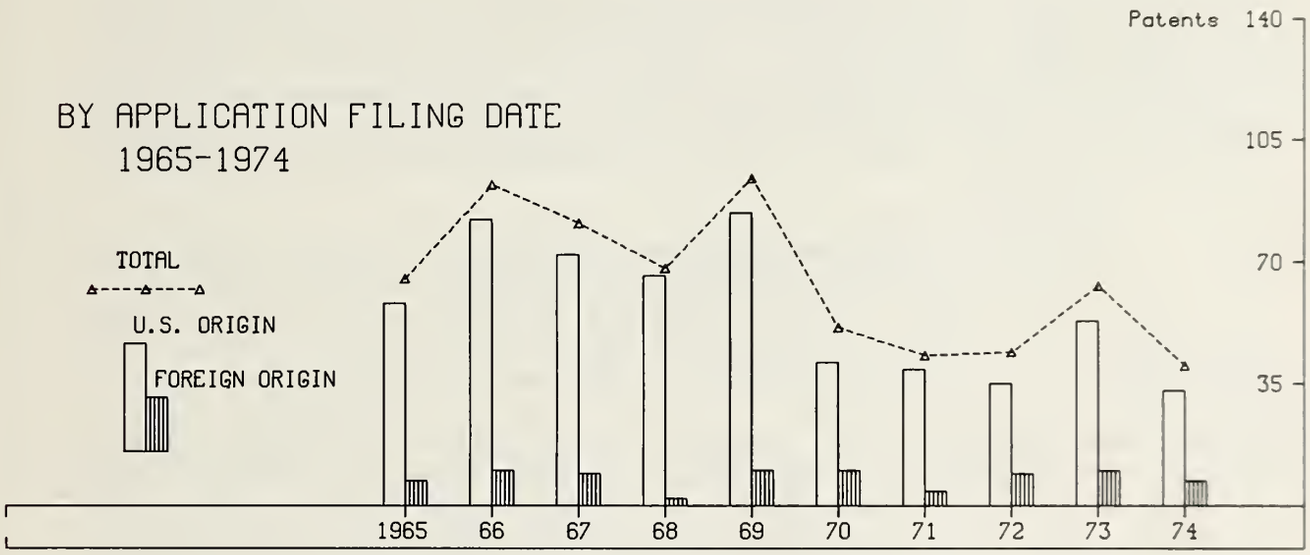
The basic patent for seismic exploration was issued in September of 1926 to Ludger Mintrop (2). Mintrop's method consisted principally of detonating a charge of explosive at a point near the surface of the earth and receiving the resultant seismic waves refracted from the subsurface at plural detector points spaced from the position of the explosion. By observing the travel time of the seismic waves, subsurface strata structures along which the seismic waves traveled with greater velocity, could be detected.

---

*Numbers in parentheses refer to patents and non-patent publications listed in the bibliography at the end of this report.

# PATENT ACTIVITY




## DISTRIBUTION OF PATENTS IN AREA OF INTEREST

| | BY PATENT GRANT DATE | | | | | | | | | | TOTAL | BY PATENT APPLICATION FILING DATE | | | | | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1967 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 67-76 | 1965 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 65-74 |
| TOTAL PATENTS | 127 | 91 | 76 | 77 | 74 | 72 | 62 | 49 | 68 | 51 | 747 | 65 | 92 | 81 | 68 | 94 | 51 | 43 | 44 | 63 | 40 | 641 |
| UNITED STATES | 122 | 77 | 68 | 73 | 68 | 61 | 53 | 39 | 62 | 40 | 663 | 58 | 82 | 72 | 66 | 84 | 41 | 39 | 35 | 53 | 33 | 564 |
| TOTAL FOREIGN | 5 | 14 | 8 | 4 | 6 | 11 | 9 | 10 | 6 | 11 | 84 | 7 | 10 | 9 | 2 | 10 | 10 | 4 | 9 | 10 | 7 | 78 |
| FRANCE | | 4 | 2 | 2 | 4 | 4 | 5 | 7 | 4 | 5 | 37 | 2 | 2 | 4 | 1 | 5 | 6 | 2 | 5 | 7 | 3 | 37 |
| UNITED KINGDOM | 2 | 2 | 3 | 1 | 2 | 1 | | | | 4 | 15 | 3 | 1 | 1 | | 3 | | | | 1 | 2 | 11 |
| CANADA | 2 | 4 | 1 | 1 | | 2 | | | 1 | | 11 | 1 | 4 | 2 | | | 2 | | | 1 | | 10 |
| GERMANY | 1 | 1 | 1 | | | | | 1 | 1 | 1 | 6 | | 1 | 1 | | | | | 1 | 1 | 1 | 5 |
| JAPAN | | 1 | | | | 1 | | | | 1 | 3 | | | 1 | 1 | | | | | | 1 | 3 |
| VENEZUELA | | | | | | | 1 | | | | 1 | | | | | 1 | | | | | | 1 |
| SWEDEN | | 1 | | | | | 1 | 1 | | | 3 | | 1 | | | | 1 | 1 | | | | 3 |
| NETHERLANDS | | | 1 | | | 1 | | | | | 2 | | 1 | | | 1 | | | | | | 2 |
| U.S.S.R. | | | | | | 1 | 1 | | | | 2 | | | | | | | 1 | 1 | | | 2 |
| ALL OTHER (4) | | 1 | | | | 1 | 1 | 1 | | | 4 | 1 | | | | | 1 | | 2 | | | 4 |

Following Mintrop's patent, the first of a series of basic patents for the reflection method of seismic surveying issued to Burton McCollum (3,4). McCollum determined the travel velocity of the seismic waves by measurements taken in bore holes in the survey area, and used the velocity data to determine the depth and dip of buried structures (4). In 1928 he received a patent for the method of implementing an electrically driven vibrator for producing wave beating between the direct and subsurface reflected seismic waves in order to determine the contour of subsurface structures (5).

In 1929 McCollum received patents for the determination of the slope of subterranean strata by either using plural geophones or successively moving one geophone, detecting reflected seismic waves, and calculating the length differences of the vertical components of the paths of the seismic waves (6,7).

During the early 1930's, automatic gain control was developed (8,9) to suppress large amplitude seismic signals that tend to obscure or confuse sup-subsequent weaker reflections. In the 1 to 6 second time period* that is required for seismic signals to travel from shot point to subsurface reflectors and back, automatic gain control offsets the tremendous fall off in signal strength from the early, or shallow, reflectors to the late, or deep, reflectors.

In the mid 1930's, multichannel seismic recording utilizing multiple receivers was developed. Originally seismic records contained as few as two traces (10,11). By 1936, the standard number was 6 (12,13); by the early 1940's, 12. Now 48 channel systems are the most common, but larger numbers, up to 256 channels, are occasionally used.

Magnetic recording tape was introduced in the 1950's (14,15) in order to provide a viable method of recording the entire reflection signal. This eliminated the need for more than one shot at each survey point, and reduced consumption and cost of seismic wave sources. Magnetic tape also provided a mode of replaying the data signals with different filter settings, thereby permitting the determination of the optimum corrections for the recorded data.

In January of 1956, the U.S. Patent and Trademark Office issued a patent (16) to W.H. Mayne for a process of common depth point stacking (CDP), purported to be one of the most significant advances to date in the seismic method and the single most important invention to date in seismic signal processing (17). In the CDP method, geophone signal traces, which are recorded from shot points at different horizontal locations on the ground surface, but which reflect from the same subsurface point, are stacked (added). The summing of CDP traces improves data signals because primary common reflection point (CRP) reflections are in phase and add constructively, whereas ambient noise and other seismic signals which are not in phase, cancel. This compositing increases reflection signal-to-noise ratios by factors approaching $\sqrt{N}$, where N is the number (fold) of CDP traces summed.

---

* Seismic traces seldom exceed six seconds in length because hydrocarbon reserves rarely occur below 30,000 feet in geological basins. At these depths acoustic wave velocities average 15,000 ft/sec.

In the mid 1950's, digital processing and recording were first applied to seismic signal processing (18-21). Digital techniques, such as binary gain ranging (20) and floating point amplification were incorporated into seismic recording instruments (22, 23). Digital seismic recording systems presently have dynamic ranges of approximately 80 dB. Reflection amplitudes decay about 100 dB in the first 4 seconds of recording, primarily due to attenuation losses along the travel path. Consequentially, amplifier gain levels change many times during recording in order to preserve signal amplitude for subsequent processing.

Digital processing was also applied to seismic signals in order to provide static (24) and dynamic (25) corrections. Static corrections consist of the application of a time shift, or translation, to an entire signal trace so that a constant time correction term is added or subtracted from all reflection times, regardless of record time or reflector depth. Dynamic corrections vary with record time and therefore depend on reflector depth. Correction for weathering (velocity changes near the earth's surface due to the makeup of the strata) (24), and elevation (24) are static type changes. Correction of CDP traces for travel time differences, caused by varying ray path distances prior to stacking, is termed "normal moveout" (NMO), which is a dynamic correction as it depends on the depth (record time) to the reflecting horizon (26).

Several recent court decisions* dealing with the patentability of inventions drawn to computer programs, operations and algorithms have drastically affected patenting in the field of digital processing.

---

* In the Benson[1] decision, the United States Supreme Court modified the prior standard as was set forth by the Court of Customs and Patents Appeals (CCPA) in Musgrave[2] and Foster,[3] which had been favorable to the patentability of certain computer programs and algorithms. The Benson decision resulted in a dramatic decrease in the number of applications directed toward geophysical computer programs, algorithms and processing formulae. However, a more recent CCPA decision -- In re Chatfield[4] -- which, in general, supports the patentability of certain programs and algorithms, has, in effect, been upheld by the Supreme Court by virtue of its refusal to review the decision (denial of certiorari). This may result in a significant increase in patent applications in this area. Those readers interested in learning more about this matter are referred to the court decisions cited below.

1. Gottschalk v. Benson, 409 U.S. 63, 175 U.S.P.Q. 673 (1972)
2. In re Musgrave, 57 C.C.P.A. 1352, 431 F.2d 882, 167 U.S.P.Q. 280 (1970)
3. In re Foster et al, 58 C.C.P.A. 1001, 438 F.2d 1011, 169 U.S.P.Q. 99 (1971)
4. In re Chatfield, 545 F.2d 152, 191 U.S.P.Q. 730 (C.C.P.A. 1976), certiorari denied, 46 U.S.L.W. 3203 (Oct. 4, 1977)
5. In re Christensen, 478 F.2d 1392, 178 U.S.P.Q. 35 (C.C.P.A., 1973)
6. In re Deutsch, 553 F.2d 689, 193 U.S.P.Q. 645 (C.C.P.A. 1977)
7. In re Waldbaum, ___ F.2d ___, 194 U.S.P.Q. 465 (C.C.P.A. 1977)
8. 954 O.G. 1362
9. In re Castelet, ____ F.2d ____, U.S.P.Q. ____ (C.C.P.A. 1977)
10. In re Flook, ____ F.2d ____, U.S.P.Q. ____ (C.C.P.A. 1977)

Because many developments in methods of digital machine processing have not been patented, patent statistics for this area of seismic signal processing do not reflect all activity in this area.

Thrust of the Technology

Since the basic objective of all seismic processing is to convert the information recorded in the field into a form that best facilitates geological interpretation, recent efforts have been primarily directed to digital data processing of the seismic survey data (27-29). For a typical survey, to build up a three-dimensional picture of the subsurface geology in a one square mile region, 50 million bits of information are obtained for processing (30). Processing of such massive amounts of data necessitates the use of digital computers.

Digital Wiener shaping filters have been developed (28) to extract the desired seismic signal from ambient noise. Criteria have been developed for deriving filter operators which, when convolved with recorded traces, yield an output as close as possible to the desired signal. Wiener filters have been designed to remove undesired repetition (ghosts) of primary reflection signals caused by downward reflection of energy from the shot at interfaces above the shot (29).

Weiner filtering has also been applied to the problem of removing coherent noise that has a moveout time or apparent velocity different than the desired reflection events (30). This filtering operation is based on the time differential, for a particular event, between adjacent seismic signal traces.

Low cut frequency filtering and wave number filtering have been developed to reduce the low velocity, low frequency, surface wave interference (groundroll), which, due to its high amplitude level, masks useful reflection information (31, 32).

Filters have also been invented to preserve relative amplitudes in seismic signals (33). The amplitude information has been used primarily in amplitude anomaly (bright spot) studies to pinpoint changes in rock composition, strata thickness and stratigraphic conditions (34, 35). The bright spot technique is based upon the principle that gas saturated sands have a lower acoustic wave velocity than adjacent water or oil saturated sands, so that the velocity contrasts across surfaces bounding the gas zones, above or below, would cause reflections of higher amplitude than would be observed from the same interface on either side of the gas zones. In order to obtain accurate amplitude measurements, corrections are made for spherical spreading, attenuation, and interference (constructive or destructive) between reflections from nearby interfaces, as well as distortions due to processing operations, e.g., convolution and focusing effects due to the curvature of reflecting interfaces.

In order to preserve relative reflection amplitude variations in seismic signals, inverse gain functions have been developed in two categories, statistical and deterministic. Both approaches attempt to correct traces for average attenuation rates while preserving instantaneous variations caused

by changes in subsurface acoustic impedances. Deterministic approaches define general models to describe many of the possible factors affecting amplitudes, such as diverging wavefronts, selective frequency absorption, reflection and transmission losses and source plus receiver array effects. Statistical approaches produce average gain functions based on collections of traces sorted by a common range, source or receiver (36).

Seismic data is also enhanced by deconvolution filtering (37). This type of processing is generally applied to reduce the peaking of the frequency response due to the reverberation of the seismic signal between two strata surfaces, and to improve the resolution of seismic signals by building up higher frequencies as the spectrum is whitened.

Holographic systems, such as the one shown in Figure 5, have been developed to provide a three dimensional view of the subsurface strata (38, 39, 40). In this process coherent acoustic energy is transmitted into the earth and detected by an areal array of geophones. A reference signal obtained from the energy source is delayed, amplified and mixed with the signals from the areal detectors to form the acoustic hologram. Reconstruction of the subsurface image from the hologram shows the reflecting surfaces and the source pattern image.

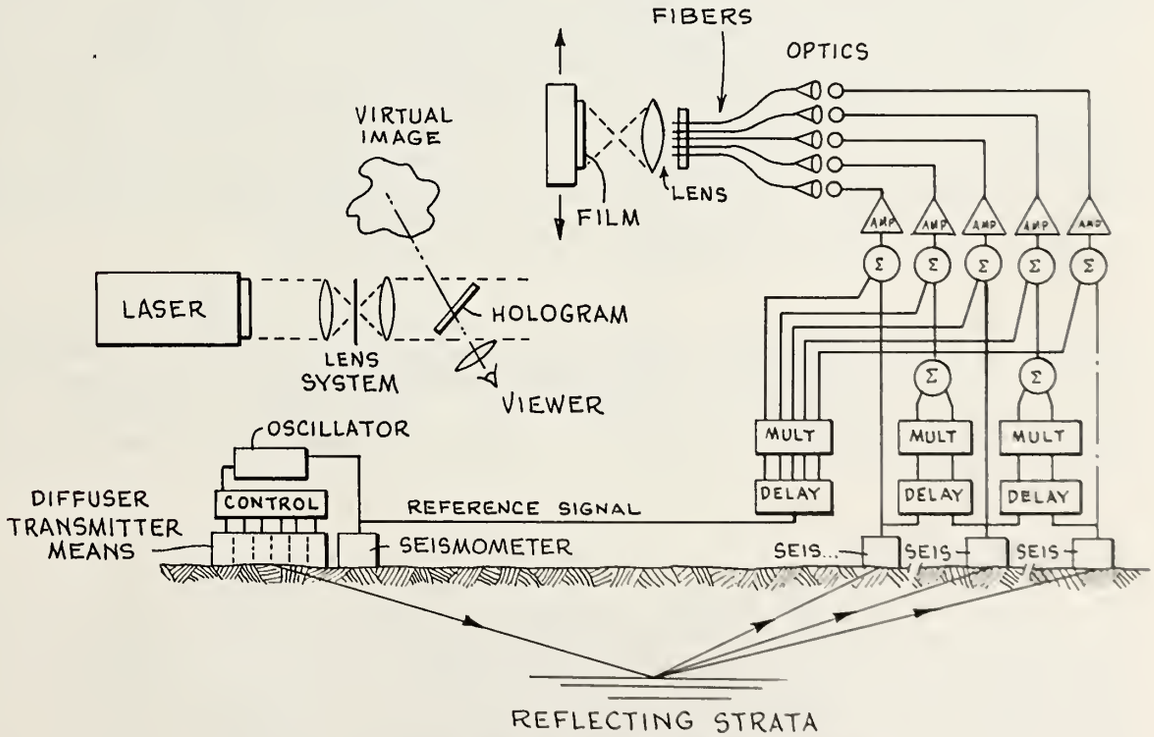



*FIG. 5: SEISMIC HOLOGRAPHY*

A beam steering method has been developed to provide three dimensional visualization of the subsurface strata by emphasizing signal energy received from a particular direction (41,42). In this method successive channels are delayed so that events of a certain dip moveout (or apparent velocity) occur at the same time and are then summed. This procedure is repeated for successive different dip moveouts, in effect, to steer the seismic waves for other dips.

Seismic data processing systems have also been developed to control the emitted seismic signals in order to optimize the characteristics of the signal received for further processing. One such system applies a variable frequency signal at the surface of the earth for a substantial period of time (13 seconds) (43). In this system the waves received at the various geophone locations, set up to receive the vibrations reflected from subsurface discontinuities, are crosscorrelated with a signal representing the vibrations transmitted into the ground to produce a correlated signal in which the various reflected waves appear as discrete wavelets. Later developments (44-46) to this process have provided for the use of discrete wave groups of constant frequency in series.

Another method developed to optimize received seismic signals by minimizing side lobes, is the injection of randomly time-spaced signals and cross correlating the received signals (47,48).

Optical filtering systems have been invented to remove noise from seismic signals by spatial filtering (49), to remove filter reverberation noise by deconvolution (50), and to perform multi-dimensional Fourier transforms to conserve phase and amplitude information (51). The systems generally use coherent light from a laser to produce a two dimensional Fourier transform diffraction pattern by passing the beam through a transparent reduction of a variable-density or variable-area record section. The seismic signals on the record section act as an optical grating and diffract the laser light. By obstructing portions of the pattern corresponding to particular frequencies or dips on the seismic section, such frequencies or dips can be removed from the reconstructed image.

In order to determine the continuity, thickness and structure of coal deposits, developments have been made in the use of mirror symmetrical Rayleigh waves (52) and pulsed monochromatic coherent sound waves (53). These wave modes are injected into the strata, detected, processed, and recorded in order to reveal the lithological characteristics of coal beds.

## Technology Trends

The major forseeable trend in geophysical processing is the use of the mini-computer in field data acquisition systems in order to provide both automatic control functions and preliminary real time processing of the data. Since data quality often varies widely over relatively short horizontal distances due to surface weathering, layer irregularities, ghosts, etc., high density, separately recorded geophones will be used to determine both static and dynamic corrections more accurately. Higher channel density recording will be utilized to permit more accurate vertical velocity determinations.

Beam steering and seismic holography present great potential for pointing out structure and resolving stratigraphic problems when used in conjunction with two dimensional arrays of closely spaced geophones which are steered, focused, recorded, and processed by an appropriately programmed computerized field system.

Continued emphasis is predicted for the development of improved digital filters, automatic static and dynamic correction algorithms, automatic reflection picking, source wavelet extraction, three dimensional dip migrations, and computer determinations of lithologic ratios.

Technology Analysis by
Nelson Moskowitz
Patent Examiner

# BIBLIOGRAPHY


| | PATENT NO. | INVENTOR | ASSIGNEE | COUNTRY |
|---|---|---|---|---|
| 1. | Geophysical Society of Tulsa, Pamphlet, History of the Society of Exploration Geophysicists, printed for the International Petroleum Exposition, Tulsa, Oklahoma, May 15-22, 1948. | | | |
| 2. | 1,599,538 | L. Mintrop | ---------- | Germany |
| 3. | 1,672,495 | B. McCollum | ---------- | U.S.A. |
| 4. | RE 17242 | B. McCollum | ---------- | U.S.A. |
| 5. | 1,675,121 | B. McCollum | ---------- | U.S.A. |
| 6. | 1,724,720 | B. McCollum | McCollum Geological Explorations, Inc. | U.S.A. |
| 7. | 1,724,495 | B. McCollum | McCollum Geological Explorations, Inc. | U.S.A. |
| 8. | 2,003,780 | W.T. Born | Geophysical Research Corp. | U.S.A. |
| 9. | 2,008,698 | J.H. Hammond Jr. | ---------- | U.S.A. |
| 10. | 2,046,843 | H.R. Prescott et al | Continental Oil Co. | U.S.A. |
| 11. | 2,087,120 | H. Salvatori et al | Western Geophysical Co. | U.S.A. |
| 12. | 2,148,422 | L.W. Blau | Standard Oil Development Company | U.S.A. |
| 13. | 2,243,729 | L.G. Ellis | Sun Oil Company | U.S.A. |
| 14. | 3,075,607 | A.R. Aitken et al | Texas Instruments Inc. | U.S.A. |
| 15. | 3,047,836 | V.R. Johnson et al | Jersey Production Research Company | U.S.A. |
| 16. | 2,732,906 | W.H. Mayne | Olive S. Petty | U.S.A. |
| 17. | Geophysics, Volume 41, No.3, Pages 546-552 R.O. Lindseth, Petroleum Exploration in Canada, 1976, (see page 548) | | | |
| 18. | 2,968,022 | R.R. Unterberger | California Research Corp. | U.S.A. |
| 19. | 2,972,733 | J.F. Bucy, Jr. | Texas Instruments Inc. | U.S.A. |
| 20. | 3,134,957 | R.S. Foote et al | Texas Instruments Inc. | U.S.A. |
| 21. | 3,241,100 | R.J. Loofbourrou | Texaco Inc. | U.S.A. |
| 22. | 3,562,504 | Ralph A. Harris | Texas Instruments Inc. | U.S.A. |
| 23. | 3,924,260 | Braham et al | Petty-Ray Geophysical, Inc. | U.S.A. |
| 24. | 3,697,939 | Albert W. Musgrave | Mobil Oil Corporation | U.S.A. |
| 25. | 3,629,800 | William A. Schneider | Texas Instruments Inc. | U.S.A. |
| 26. | 3,747,055 | Eugene T. Greene, Jr. | Texaco Inc. | U.S.A. |
| 27. | 3,680,040 | Siverman et al | Amoco Production Co. | U.S.A. |
| 28. | 3,629,800 | Schneider | Texas Instruments Inc. | U.S.A. |
| 29. | 3,550,073 | M.R. Foster et al | Mobil Oil Corporation | U.S.A. |
| 30. | Oil and Gas Journal, Volume 72, No.32, Outlay for U.S. Seismic Work Hits Record High, SEG Reports, August 1974, page 64. | | | |
| 31. | 2,473,469 | C.G. Dahm | Socony-Vacuum Oil Co. Inc. | U.S.A. |
| 32. | 3,432,807 | J.P. Lindsey | Philips Petroleum Co. | U.S.A. |
| 33. | 3,652,980 | Pierre L. Goupillaud | Continental Oil Company | U.S.A. |

BIBLIOGRAPHY CONTINUED


| PATENT NO. | INVENTOR | ASSIGNEE | COUNTRY |
|---|---|---|---|
| 34. 3,921,126 | K.H. Waters | Continental Oil Company | U.S.A. |
| 35. Ocean Industry, Vol 9, No. 2, pages 60-65, Savit, Bright Spot in the Energy Picture, February 1974. | | | |
| 36. 3,774,146 | Pierre L. Goupillaud | Continental Oil Company | U.S.A. |
| 37. 3,599,175 | Hollingsworth et al | Petty Geophysical Engineering Co. | U.S.A. |
| 38. 3,691,517 | E.D. Riggs | Atlantic Richfield Co. | U.S.A. |
| 39. 3,622,968 | Daniel Silverman | Amoco Production Co. | U.S.A. |
| 40. 3,729,704 | John B. Farr | Amoco Production Co. | U.S.A. |
| 41. 3,597,727 | R.D. Judson et al | Chevron Research Co. | U.S.A. |
| 42. 3,529,282 | R.J.S. Brown et al | ---------- | U.S.A. |
| 43. 2,688,124 | Doty et al | Continental Oil Co. | U.S.A. |
| 44. 3,182,743 | B. McCollum | ---------- | U.S.A. |
| 45. 3,259,878 | J.F. Misfud | Esso Production Research Co. | U.S.A. |
| 46. 4,004,267 | Mayne | Geosource Inc. | U.S.A. |
| 47. 3,697,938 | Taner | Seismic Computing Corp. | U.S.A. |
| 48. 3,866,174 | Maurice Barbier | Societe Nationale Des Petroles O'Aquitaine | France |
| 49. 3,620,591 | Emmet D. Riggs | Atlantic Richfield Co. | U.S.A. |
| 50. 3,524,195 | D. Silverman | Pan American Petroleum Corporation | U.S.A. |
| 51. 3,872,293 | E.L. Green | The U.S.A. as represented by the Sec. of the Navy | U.S.A. |
| 52. 3,858,167 | Stas et al | Vedeckovyzkummy Uhelny Ustav | Czechoslovakia |
| 53. 3,961,307 | Hochheimer et al | Ruhrkohle Aktiengesellschaft | Germany |

## SEISMIC RECORDERS AND DISPLAYS

Recorders and displays which operate primarily in conjunction with seismic prospecting equipment, although they may also be used to record and display nuclear and electrical-magnetic geophysical information. Typical systems record and display seismic output data which has been corrected by a computer and processed so as to facilitate the operation of the disired mode of display (Class 340, subclass 15.5DS; class 346, subclassess 33C, 33WL, 107SC, 107W).

Activity Indices (1974-1976)

| | | | |
|---|---|---|---|
| Growth (10 year base) | 17.7% | Corporate Owned | 92.3% |
| Foreign Share | 15.4% | Government Owned | 0.0% |

Recent Activity

Recent patent activity has been directed towards quantitatively displaying multiple seismic signal functions or parameters by a single display with the use of multiple colors, varying areas, or varying densities. Computer controlled cathode ray oscilloscope display systems are being developed to provide pseudo-real time displays during signal processing. Patents issued since May 1975, include:

3,986,163 - Methods And Apparatus For Recording Well Logging Measurements (Elliott, Schlumberger Technology Corporation) - Discloses a multichannel cathode ray tube (CRT) recorder which records well logging data in either analog or digital form as a function of the depth at which such data was received. A representation of the CRT beam is repetitively swept across a recording medium while being modulated with representations of the well logging signals in order to produce an even density recording. The recorded traces and the area between selected recorded traces are coded in dependence on the well logging signal rate of change in order to produce a uniform coding presentation.

3,967,235 - Acoustic Velocity Logging System (Dennis et al, Mobil Oil Corporation) Discloses a cathode ray tube (CRT) used in conjunction with a continuous film recorder to form a variable density log of the acoustic velocity in the explored subsurface strata. The signal received from the subsurface sonde is recorded and applied to the intensity modulation input of the CRT, which, in response to recorded control signals, applies a trigger pulse to the sweep input of the CRT in order to intensity modulate the electron beam.

3,961,306 - Method Of Forming Color Graphic Displays From Input Data (Anstey, Seiscom Delta Inc.) - Discloses a seismic color graphic display having differing colors quantitatively identifying differing values, or ranges of values, of digitized seismic data. Numerical codes are assigned to specify the visual image densities and the relative density of each component color. The component color displays are superimposed into a composite color graphic display.

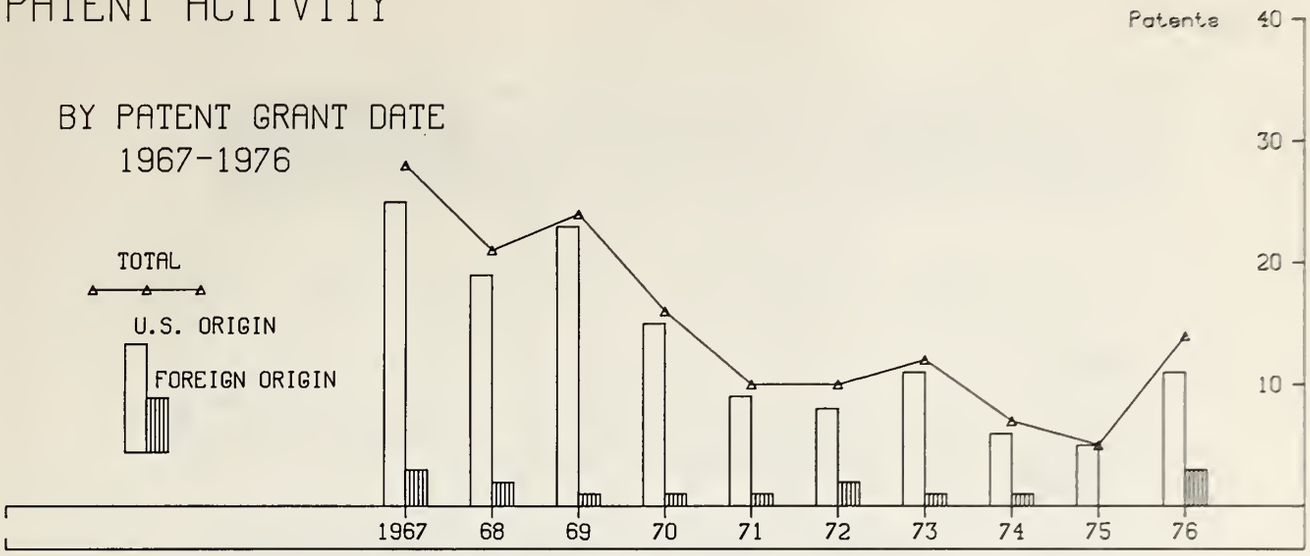
3,931,609 - Three-Dimensional Seismic Display (Anstey, Seiscom Delta, Inc.) - Discloses a method of modeling the earth's subsurface features in three dimensions by using plural processed seismic sections which are spaced apart so as to represent the disposition of the seismic profiles along their respective seismic survey lines. The individual seismic sections include a color modulation, representitive of particular geological conditions. The seismic sections are cut into slices along lines of equal reflection depth and are mounted in successive layers to represent successive layers of the earth. It is asserted that this display facilitates the picking of seismic horizons around closed loops.

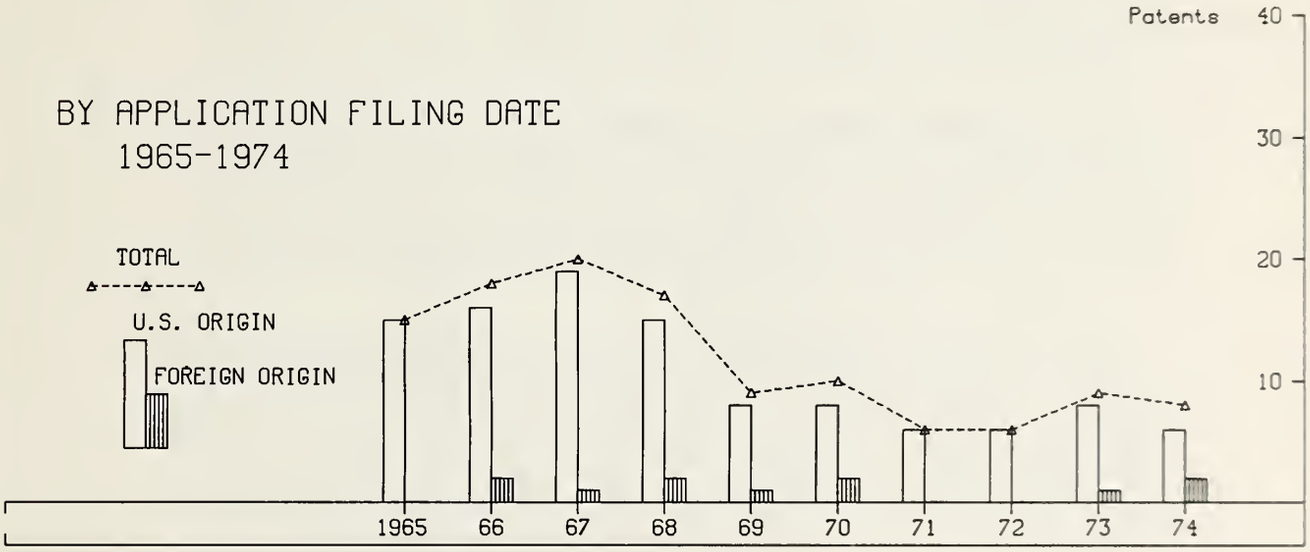
3,916,370 - Apparatus For Controlling The Transfer Of Seismic Data From Magnetic Tape Storage To A Photographic Recording (Neeley, Mobil Oil Corporation) - Discloses a seismic data processing system containing a multiplexer for applying seismic data from magnetic tape storage to a cathrode ray tube (CRT). A photographic drum plotter provides a recording of the seismic data displayed on the CRT. A timing line generator, a timing number generator, a trace mark generator, and an annotation generator apply modulation signals to the CRT to produce timing lines, timing numbers, centerline trace markings, and alpha-numeric annotation data on the photographic recording. Timing and control signals for selecting the rotational speed of the drum plotter and the data rate at which the seismic data is recorded is provided by an interface controller.

3,899,768 - Method Of Seismic Surveying By Extracting And Displaying Seismic Properties (Quay et al, Petty- Ray Geophysical, Inc.) - Discloses a method of displaying the lateral variations of seismic properties, such as, the peak frequency and energy weighted average frequency of seismic waves, occurring at or between time varying seismic boundries. Transparent overlay sheets are used for plotting of reference axes and envelopes for each of the extracted seismic properties. The overlays are then superimposed upon each other or upon the corresponding seismic record section, to the same scale, to form the final display.

3,882,446 - Interactive Horizon Building, Analysis and Editing (Brittian et al, Texas Instruments Incorporated) - Discloses a programmed computer-human interaction seismic horizon data editing system. Two dimensional graphs of primary horizon data are placed on a data tablet input to programmed computer. The computer in response to human contact through the graphs to the data tablets generates phantom horizon data with reference to coordinates of the graph. Displays are produced of segments of contiguous phantom horizons and of depth-point segments of the phantom horizons.

# PATENT ACTIVITY




## DISTRIBUTION OF PATENTS IN AREA OF INTEREST

| | BY PATENT GRANT DATE | | | | | | | | | | TOTAL | BY PATENT APPLICATION FILING DATE | | | | | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1967 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 67-76 | 1965 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 65-74 |
| TOTAL PATENTS | 28 | 21 | 24 | 16 | 10 | 10 | 12 | 7 | 5 | 14 | 147 | 15 | 18 | 20 | 17 | 9 | 10 | 6 | 6 | 9 | 8 | 118 |
| UNITED STATES | 25 | 19 | 23 | 15 | 9 | 8 | 11 | 6 | 5 | 11 | 132 | 15 | 16 | 19 | 15 | 8 | 8 | 6 | 6 | 8 | 6 | 107 |
| TOTAL FOREIGN | 3 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | | 3 | 15 | | 2 | 1 | 2 | 1 | 2 | | | 1 | 2 | 11 |
| UNITED KINGDOM | 2 | | | | 1 | | | | | 3 | 6 | | | | | 1 | | | | | 2 | 3 |
| FRANCE | | | | 1 | | 1 | 1 | | | | 3 | | | | 1 | | 2 | | | | | 3 |
| CANADA | 1 | 2 | | | | | | | | | 3 | | 1 | 1 | | | | | | | | 2 |
| NETHERLANDS | | | 1 | | | | | | | | 1 | | 1 | | | | | | | | | 1 |
| JAPAN | | | | | | 1 | | | | | 1 | | | | 1 | | | | | | | 1 |
| PERU | | | | | | | | 1 | | | 1 | | | | | | | | | 1 | | 1 |

## BOREHOLE LOGGING

Methods and apparatus for mechanically transmitting compressional waves into and/or receiving compressional waves from, an earth section, for the purpose of identifying subsurface structure. The transmitting and/or receiving occur in a shaft or a deep boring in the earth. Seismic data processing systems and mechanical acoustic wave generators particularly adapted for use in boreholes are included. (Class 181, subclasses 102-106; Class 340, subclass 15.5 A, AC, AP, BH and TI).

Activity Indices (1974-1976)

| | | | |
|---|---|---|---|
| Growth (10 year base) | 26.3% | Corporate Owned | 88.5% |
| Foreign Share | 25.0% | Government Owned | 1.9% |

Recent Activity

Recent patent activity has been directed towards minimizing road noise by threshold type data processors or mechanical acoustic wave attenuators. Activity has also been directed towards determining well-pipe and well casing condition by amplitude, frequency, and polarity analysis of reflected acoustic signals. Patents issued since June 1976 include:

3,991,850 - Noise-Attenuating Positioners For Acoustic Well-Logging Tools (Escaron, Schlumberger Technology Corporation) Discloses acoustic well logging tool bowspring positioners which maintain the tool's centering within a well bore. In order to attenuate the acoustic noise, generated by the rubbing of the outward faces of the springs along the well bore wall, the inward faces of the springs are covered with an elastomer which has interspersed throughout its length (30% of the composite volume) lead balls or pellets, 1.0-1.25 mm in diameter.

3,982,606 - Acoustical Logging Apparatus Having Signal Delay Means (Berry et al, Mobil Oil Corporation) - Discloses an acoustic well logging tool which has seismic wave attentuators intermediate the transmitter and receivers. The attenuators consist of an acoustically absorptive material, e.g. rubber sections placed in overlapping relationship and extending a distance sufficient to contact the bore. Two attenuator shapes are disclosed, rubber fingers, arranged in overlapping vertical rows, and discs, having a series of relatively large openings and stacked so that the openings are misaligned. The misalignment permits the requisite displacement of bore hole fluid while attenuating impinging acoustic waves.

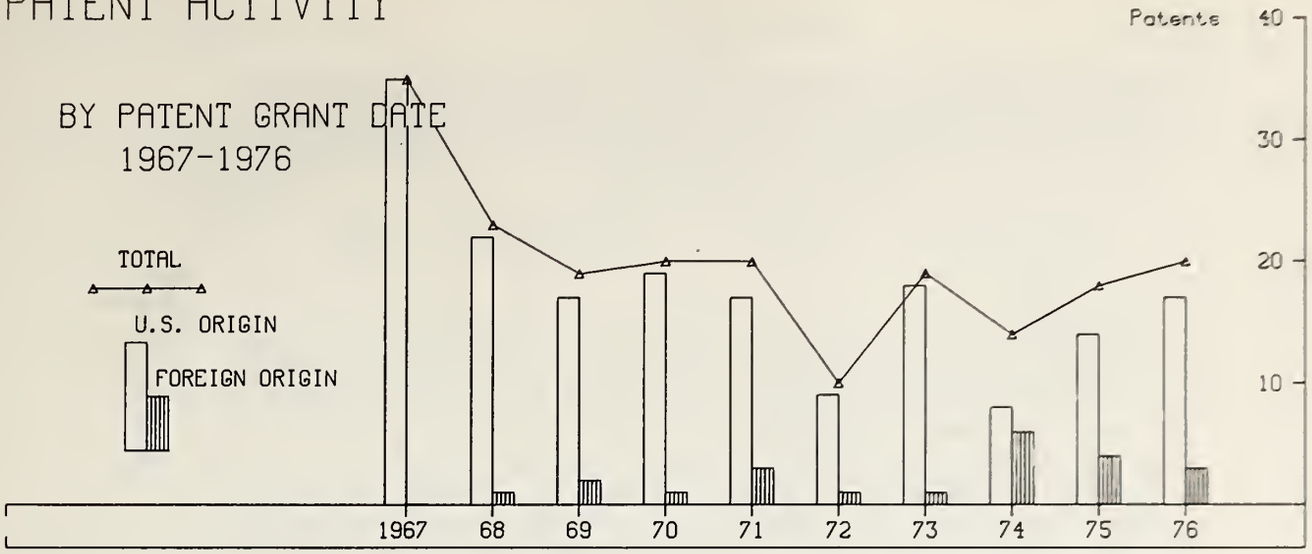
3,979,724 - Seismic Method For Determining The Position Of The Bottom Of A Long Pipe In A Deep Borehole (Silverman et al) - Discloses the determination of the position of the bottom end of a long drill pipe in a deep, water filled, borehole relative to the earth's surface. A shock wave is generated in the water, at the surface end of the pipe, and travels down the drill pipe to the bit and to the earth contiguous and adjacent to the bit. A plurality of geophones positioned in a two-dimensional array on the earth's surface detect the arrival of the shock waves emanating from the bit. The position of the bit is determined by the knowledge of the shock wave generation time, the time of travel of the shock wave in the pipe, the length of the pipe, and the arrival time of the shock wave at each geophone.

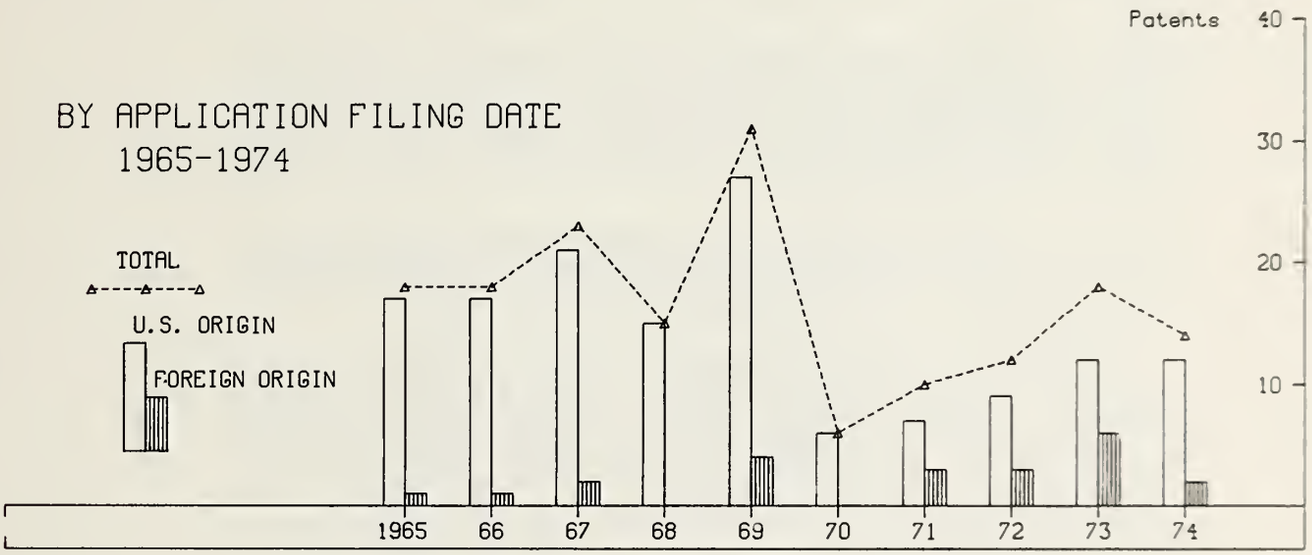
3,961,683 - Method For Determining The Shape Of An Underground Cavity And The Position Of The Surface Separating Two Media Contained Therein And Device For Carrying Out Said Method (Delignieres, Institut Francais du Petrole, des Carburants et Lubrifiants) - Discloses a system particularly adapted for determining the shape and the filling rate of an underground cavity to be used for storing petroleum products. A sequence of acoustic pulses is transmitted along each of successive transmission axes in the direction of the cavity walls from reference locations within the cavity. The average propagation time intervals of selected acoustic wave echoes are measured for each different location and direction of the logging tool in order to provide tool-to-wall distances.

3,962,674 - Acoustic Logging Using Ultrasonic Frequencies (Howell, Atlantic Richfield Company) - Discloses the determination of subsurface formation porosity and permeability by ultrasonic (one kHz to one MHz) logging. A uniform sinusoidal acoustic pulse is transmitted into the formation to be logged; the pulse is converted by the formation into an early arriving primary formation pulse and a later arriving fluid pulse which travels exclusively through interconnected fluid paths in the formation. These two pulses are detected, identified and quantized with cross correlation techniques to give a direct indication of formation permeability, to identify the formation fluid, and to determine the formation porosity.

3,949,352 - Velocity Logger For Logging Intervals (Vogel, Shell Oil Company) - Discloses an ultrasonic well logging system which detects shear waves reflected from the surrounding formation. Highly directional piezoelectric transducers designed to operate at frequencies greater than 50kHz are used both as the ultrasonic wave transmitters and wave receivers. The direction of maximum response of the transducers is made to be included at an angle less than 90° (preferably 10°-30°) from the normal to the borehole wall. The detected shear waves are processed to determine both the transmission time and the attenuation of the shear waves between the transmitter and receiver.

# PATENT ACTIVITY




## DISTRIBUTION OF PATENTS IN AREA OF INTEREST

| | BY PATENT GRANT DATE | | | | | | | | | | TOTAL | BY PATENT APPLICATION FILING DATE | | | | | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1967 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 67-76 | 1965 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 65-74 |
| TOTAL PATENTS | 35 | 23 | 19 | 20 | 20 | 10 | 19 | 14 | 18 | 20 | 198 | 18 | 18 | 23 | 15 | 31 | 6 | 10 | 12 | 18 | 14 | 165 |
| UNITED STATES | 35 | 22 | 17 | 19 | 17 | 9 | 18 | 8 | 14 | 17 | 176 | 17 | 17 | 21 | 15 | 27 | 6 | 7 | 9 | 12 | 12 | 143 |
| TOTAL FOREIGN | | 1 | 2 | 1 | 3 | 1 | 1 | 6 | 4 | 3 | 22 | 1 | 1 | 2 | | 4 | | 3 | 3 | 6 | 2 | 22 |
| FRANCE | | 1 | 1 | 1 | 2 | 1 | 1 | 4 | 3 | 2 | 16 | 1 | 1 | 1 | | 3 | | 1 | 3 | 5 | 1 | 16 |
| GERMANY | | | 1 | | 1 | | | 1 | 1 | 1 | 5 | | | 1 | | 1 | | 1 | | 1 | 1 | 5 |
| SWEDEN | | | | | | | | 1 | | | 1 | | | | | | | 1 | | | | 1 |

## SEISMIC VIBRATORS

Seismic wave sources which provide an oscillatory vibrational motion in the earth section to which they are contiguous. The vibrators may contain hydraulically driven reaction masses operating at low speeds or electrically driven eccentric masses rotating at high speeds. (Selected patents from Class 181 and Class 340).

Activity Indices (1974-1976)

| | | | |
|---|---|---|---|
| Growth (10 year base) | 40.8% | Corporate Owned | 60.0% |
| Foreign Share | 0.0% | Government Owned | 0.0% |

Recent Activity

Recent patent activity has focussed on vibrator phase lock systems and, in particular, phase control systems which operate in a feedback mode. Recent activity also has been directed to multi-unit vibrators or multivibrator systems which modulate the separate units or vibrator outputs in order to approximate an optimum transmitted seismic wave. Patents issued since February 1975 include:

4,026,383 - Gyroscopic Vibrator (Bedenbender et al, Texas Instruments Incorporated) - Discloses a vibrational energy source which has a high inertia gyroscopic mass rotating at high angular velocity about a shaft. A control force is used to impart an oscillatory angular displacement to the shaft in a plane perpendicular to the vector direction of the source. This displacement produces a gyroscopic reactionary moment in the shaft which is mechanically coupled to the earth's surface to produce oscillatory waves.

3,984,805 - Parallel Operation Of Seismic Vibrators Without Phase Control (Silverman) - Discloses a vibrator control system in which a sweep or reference signal directly drives one or more vibrators. Sensors placed directly on the vibrator generate a signal representative of the seismic vibrational wave injected into the earth. This signal is used to phase shift the reference signal so as to provide a counterpart signal which is in phase with the transmitted signals. The counter part signal is correlated against the received seismic signal.

3,983,957 - Method And Apparatus For Creating Seismic Waves In The Earth (Silverman) - Discloses a vibrator having a two part chamber, one part in contact with the earth, the other part supporting a seismic reaction mass. The chamber is hydraulically expanded so as to lift the mass above the earth. By modulating the hydraulic pressure in the chamber, seismic waves are induced into the earth.

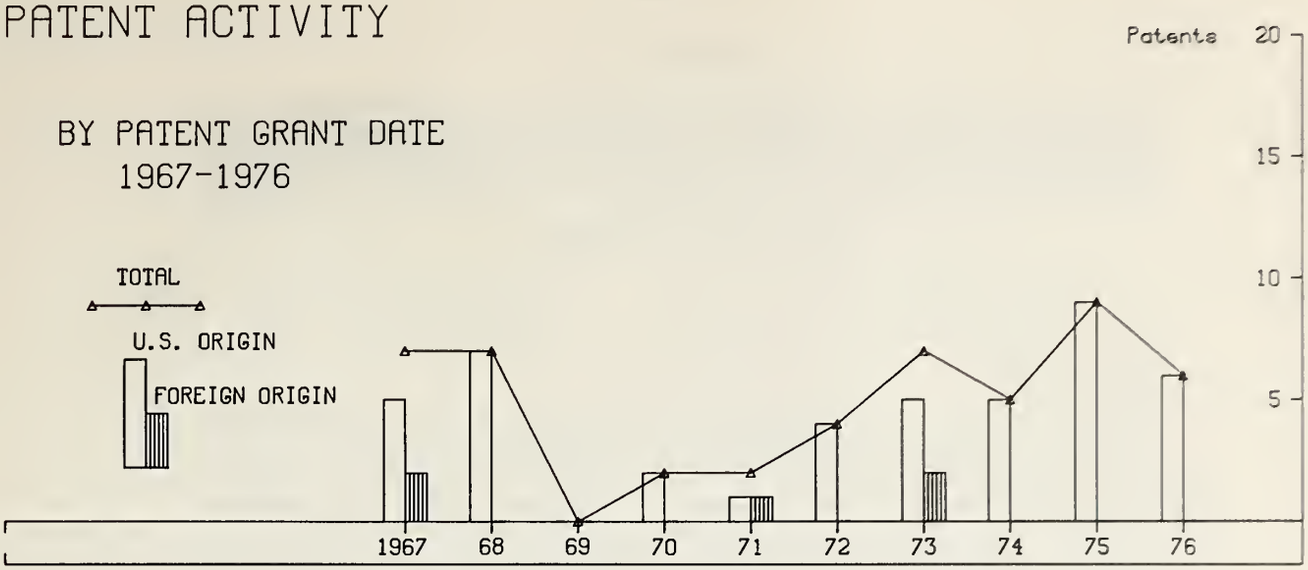
3,979,715 - Method And System For Achieving Vibrator Phase Lock (Hufstedler et al, Texas Instruments Incorporated) - Discloses a phase lock control for a "chirp signal", i.e., a sinusoidal signal with a linearly increasing or decreasing frequency, driven seismic vibrator. On the upsweep section of the chirp, when the phase error is greater than a preset threshold level, phase lock is achieved by slowing down the drive signal, so as to allow the baseplate signal to fall back into phase with the chirp signal. On downsweeps, when the phase error is above a preset threshold, phase lock is achieved by speeding up the drive signal so as to allow the baseplate signal to catch up with a reference signal.

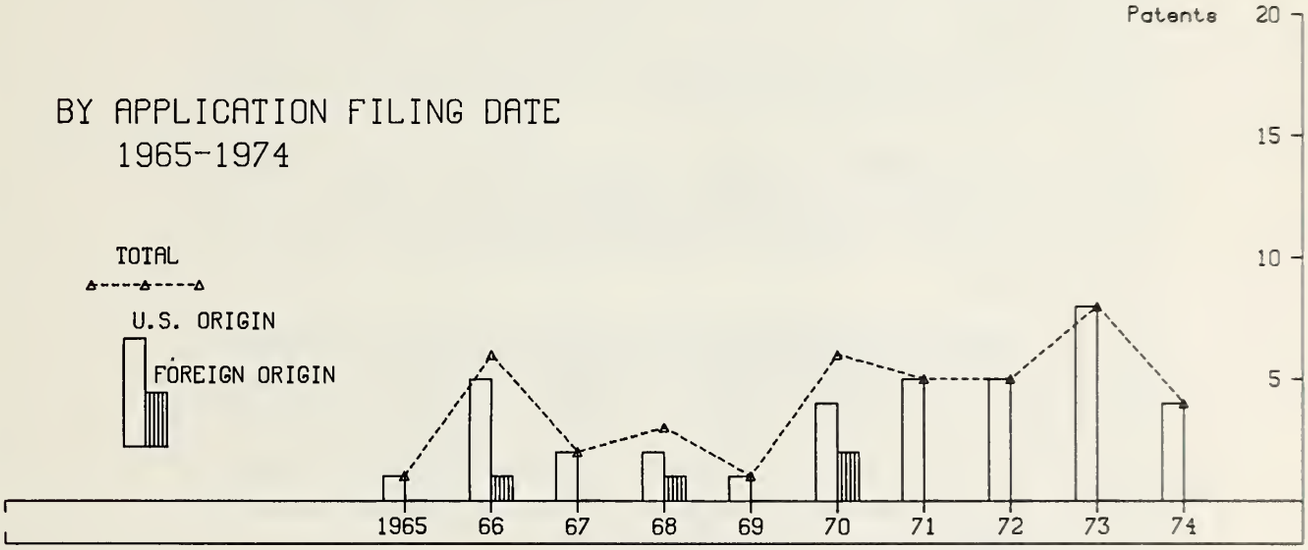
3,909.776 - Fluidic Oscillator Seismic Source (Broding et al, Amoco Production Company) - Discloses a variable frequency fluidic oscillator which is particularly adapted for use in a well for vertical prospecting. The oscillator operates by the modulation of the pressure and volume of a fluid within a bistable fluidic circuit. It is asserted that the oscillator can be repetitively pulsed at the same frequency-time pattern thereby permitting the summing of geophone responses of a plurality of oscillator cycles.

3,884,324 - Mounting For Seismic Vibrator (Hamilton et al, Hamilton Brothers Oil Company) - Discloses a tracked, rough terrain seismic exploration vehicle which is adopted to carry a vibrator on a rocker frame. The vibrator utilizes a reaction mass that can be linearly reciprocated in order to permit a base plate, which is connected to the reaction mass to be driven into, and out of engagement with the ground. The vibrator is acoustically isolated from the seismic vehicle by air bags which surround the reaction mass and dampen vertical and horizontal vibrations in a manner that concentrates the appplication of force in a downward direction.

3,866,709 - Vibratory Seismic Energy Generator (Mifsud, Exxon Production Research Company) - Discloses an electrohydraulically operated vibrator which contains a single power piston connected to a circular base plate. The base plate is held against the ground by a reaction mass, e.g. the transporting vehicle. By varying the hydraulic pressure on opposite sides of the power piston, reciprocating movement and concomitant acoustic vibrations are produced.

# PATENT ACTIVITY




## DISTRIBUTION OF PATENTS IN AREA OF INTEREST

| | BY PATENT GRANT DATE | | | | | | | | | | TOTAL | BY PATENT APPLICATION FILING DATE | | | | | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1967 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 67-76 | 1965 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 65-74 |
| TOTAL PATENTS | 7 | 7 | | 2 | 2 | 4 | 7 | 5 | 9 | 6 | 49 | 1 | 6 | 2 | 3 | 1 | 6 | 5 | 5 | 8 | 4 | 41 |
| UNITED STATES | 5 | 7 | | 2 | 1 | 4 | 5 | 5 | 9 | 6 | 44 | 1 | 5 | 2 | 2 | 1 | 4 | 5 | 5 | 8 | 4 | 37 |
| TOTAL FOREIGN | 2 | | | | 1 | | 2 | | | | 5 | | 1 | | 1 | | 2 | | | | | 4 |
| FRANCE | 1 | | | | | | 1 | | | | 2 | | | | | | 1 | | | | | 1 |
| CANADA | | | | | | | 1 | | | | 1 | | | | | | 1 | | | | | 1 |
| GERMANY | 1 | | | | | | | | | | 1 | | 1 | | | | | | | | | 1 |
| U.S.S.R. | | | | | 1 | | | | | | 1 | | | | 1 | | | | | | | 1 |

## AIR GUNS

Seismic wave generators which release compressed gases. The gas expands creating a compressional wave front which is transmitted, by acoustic coupling, to the subsurface strata which is to be explored and mapped. Although primarily designed for offshore use, air guns specifically designed for land use have been developed. (Selected patents from Class 181 and Class 340).

Activity Indices (1974-1976)

| | | | |
|---|---|---|---|
| Growth (10 per year base) | 32.7% | Corporate Owned | 94.1% |
| Foreign Share | 11.8% | Government Owned | 0N0% |

Recent Activity

Recent patent activity has been directed towards the use of mechanical shields and air release controls in order to minimize the noise produced by air bubble oscillation. Multi-unit air gun systems have been developed to permit shaping of the transmitted seismic signal by controlling the time of air release, the amount of air released, and the order in which the units release the air. Patents issued since July 1975 include:

4,016,951 - Air Transportable Seismic Exploration System For On Ice-Covered Waters (Dick et al, Western Geophysical Company of America) - Discloses a high pressure (4,000 to 7,000 p.s.i.) air gun surveying system to be used in ice covered waters and at low temperatures (-35° to -60° F). A small enclosed, helicopter transportable, insulated shelter (6 feet high, 6 feet long, and 5 feet wide) is provided to house the air gun, auxillary equipment, and operating personnel and provide protection from adverse environmental conditions. The heat generated by the auxiliary equipment is used to prevent freezing of the air gun and to provide the operating personnel with a relatively warm environment.

4,008,784 - Seismic Signal Source (Bays, Seiscom Delta Inc.) - Discloses a vehicle mounted air gun system for use in seismic exploration over a land surface. Air guns are mounted on the rims of the vehicle's fluid-filled tires to provide compressed air which is directed to impinge upon diaphragms in the tires. The compressed air causes the diaphragm to expand and accelerate the fluid in the tire, which exerts a force on the land surface through the tire, thereby imparting a seismic signal to the land surface.

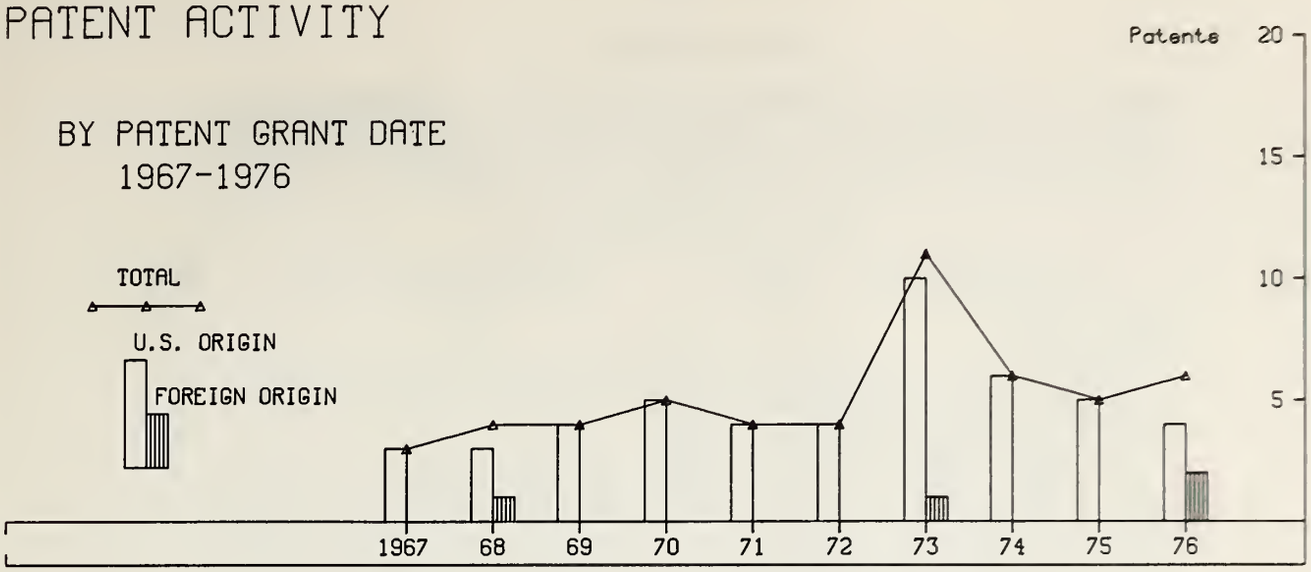
4,006,794 - Seismic Pneumatic Energy Source With Flap Valves For Attenuation Of Bubble Pulse Amplitute And Reduction of Period Of Bubble Oscillation (Itria, Texaco, Inc.) - Dicloses an air gun which flattens the bubble of released air and prevents the bubble from contracting back into the body of the air gun. Air deflectors are mounted at the exit ports of the gun and are connected to cylinders which straighten and hold the exhausting air in a designated direction. A spring operating at 200 p.s.i. is provided to close the air release valves when the air pressure becomes neutralized, just prior to the bubble reaching its maximum size and collapsing back into the cylinder. It is asserted that the elongated and flattened air bubble will collapse under hydrostatic pressure with reduced impact and, as a result, the bubble pulse period and amplitude are considerably reduced.

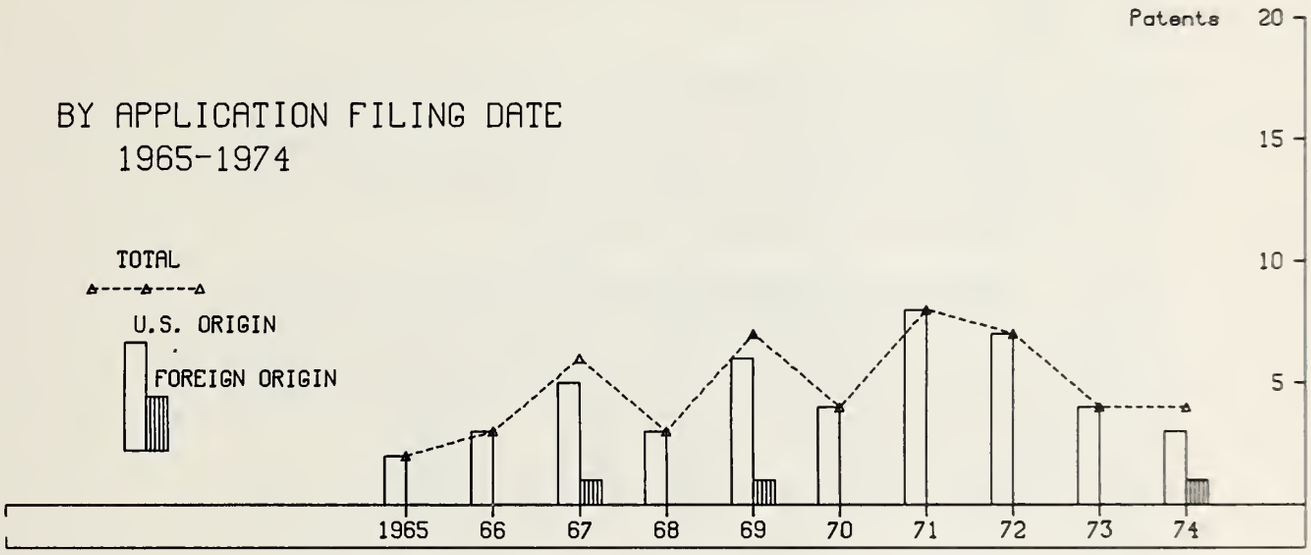
3,979,140 - Seismic Method For Logging Position Of A Deep Borehole In The Earth (Silverman et al, Senturion Sciences, Inc.) - Discloses a compressed fluid seismic wave generator for use in liquid filled deep boreholes. Compressed liquids or gases are injected from the surface of the earth into a pipe which extends into the borehole. Fast action electrically controlled valves permit the compressed fluid to explosively expand into the liquid in the annulus of the borehole and cause seismic waves to be generated.

3,896,898 - High Frequency Seismic Source Using Compressed Air (Kirby et al, Exxon Production Research Company) - Discloses an air gun which has compressed air stored in a reservoir and which is mounted on a platform for use beneath the surface of a liquid medium. The compressed air is simultaneously released into a plurality of conduits of equal lengths, but unequal diameter, which are arranged in an areal pattern on the platform. The tubes are .5 to 5 meters in length and .5 to 5 centimeters in diameter. It is asserted that the simultaneous release of compressed air through the individual conduits will produce seismic waves which add algebraically to produce a single, high energy, high frequency pulse.

3,893,539 - Multiple Air Gun Array Of Varied Sizes With Individual Secondary Oscillation Suppression (Mott-Smith, Petty-Ray Geophysical, Inc.) - Discloses a ship-towed system of plural air guns of different sizes (70-450 cubic inches) and interspacings (8-14 feet) which are operated simultaneously. It is asserted that this system generates a seismic pulse which defines a signature having a signal-to-bubble ratio of from (8-1) through (12-1). The air guns' interspacing is set to avoid coalescence of adjacent air bubbles and 25% to 33% of the total air gun volume is used to provide a secondary bubble within the first bubble in order to lengthen the total bubble collapse time.

# PATENT ACTIVITY




## DISTRIBUTION OF PATENTS IN AREA OF INTEREST

| | BY PATENT GRANT DATE | | | | | | | | | | | BY PATENT APPLICATION FILING DATE | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1967 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | TOTAL 67-76 | 1965 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | TOTAL 65-74 |
| TOTAL PATENTS | 3 | 4 | 4 | 5 | 4 | 4 | 11 | 6 | 5 | 6 | 52 | 2 | 3 | 6 | 3 | 7 | 4 | 8 | 7 | 4 | 4 | 48 |
| UNITED STATES | 3 | 3 | 4 | 5 | 4 | 4 | 10 | 6 | 5 | 4 | 48 | 2 | 3 | 5 | 3 | 6 | 4 | 8 | 7 | 4 | 3 | 45 |
| TOTAL FOREIGN | | 1 | | | | | 1 | | | 2 | 4 | | | 1 | | 1 | | | | | 1 | 3 |
| UNITED KINGDOM | | | | | | | | | | 1 | 1 | | | | | | | | | | 1 | 1 |
| FRANCE | | | | | | | 1 | | | | 1 | | | | | 1 | | | | | | 1 |
| CANADA | | | | | | | | | | 1 | 1 | | | | | | | | | | | |
| U.S.S.R. | | 1 | | | | | | | | | 1 | | | 1 | | | | | | | | 1 |

## SOLID EXPLOSIVES

Seismic wave generators wherein solid materals are processed to react exothermically and create shock waves for geophysical exploration. Typically, in offshore prospecting the explosive is cartridge contained and percussion initiated; while in land prospecting the explosive is packaged as a cord or in elongated cylinders and is electrically ignited. (Selected patents from Class 181 and Class 340).

Activity Indices (1974-1976)

| | | | |
|---|---|---|---|
| Growth (10 year base) | 27.6% | Corporate Owned | 87.5% |
| Foreign Share | 25.0% | Government Owned | 8.3% |

Patent Activity

Recent patent activity has been primarily directed to systems using solid explosives in offshore prospecting. The systems provide for handling the explosives in a cartridge mode and projecting the cartridge to the desired explosion area by fluid pressure. Patents issued since September 1975 include:

3,971,319 - Thermally Actuated Percussion Initiatable Explosive Cartridge Assembly (Larson, Hercules Incorporated) - Discloses an explosive cartridge which is thermally actuated and specifically designed for land seismic use. A thermostatic percussion initiator consisting of a pair of opposed convex and concave curved metal strips (copper/brass and iron/nickel) which have different coefficients of thermal expansion is used to drive a pin, by snap action, into the percussion sensitive area of the explosive cartidge in response to a temperature increase caused by hot fluid directed at the cartridge.

3,968,855 - Seismic Marine Gun Assembly (Mollere, Hercules Incorporated) - Discloses a towed underwater gun assembly which includes an acceleration barrel, which is resiliently coupled to and separable from the firing gun. Percussion initiatable explosive cartridges are accelerated through the barrel by a stream of water with sufficient kinetic energy to initiate the firing pin and ignite the explosive charge. It is asserted that the resilient couple absorbs the shock waves from the ambient charge explosions and, minimizes damage to the expensive accelerator barrel. If the gun is damaged it can be easily removed and replaced.

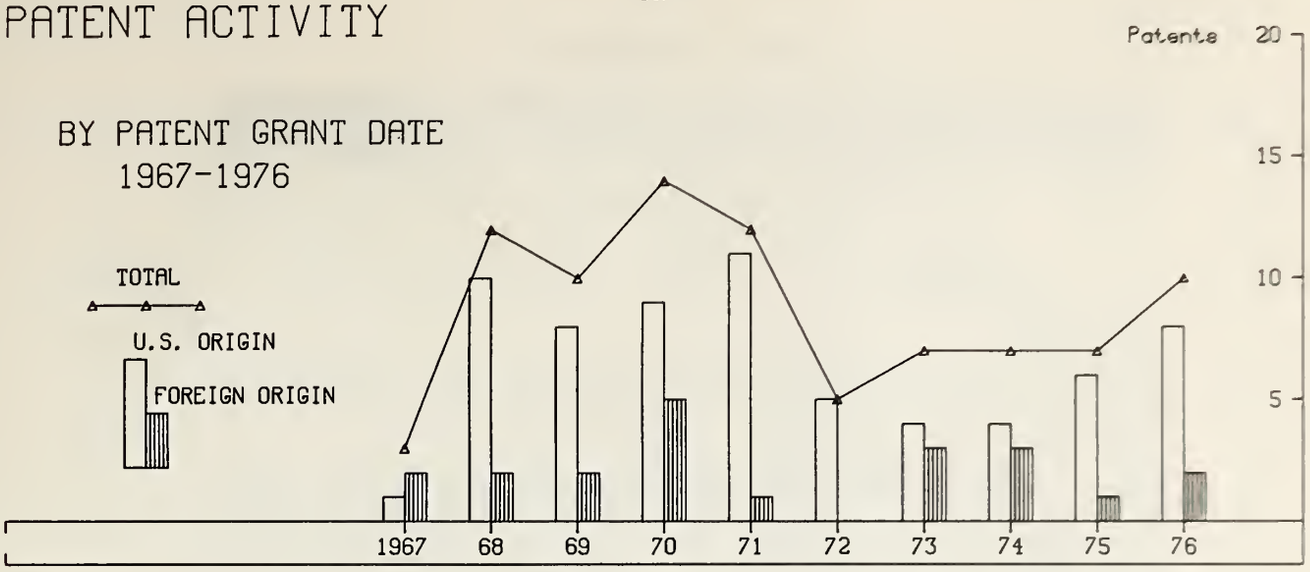
3,948,177 - Self-Disarming Explosive Cartridges (Fitch, Hercules Incorporated) - Discloses a self-disarming explosive cartridge for use in offshore seismic exploration to eliminate the hazard of unfired live cartridges being washed ashore and exploding. When the shell is fired by striking the primer, a conduit which acts as a primer well, is driven into the cartridge shell so as to break its watertight seal. The ingress and egress of ambient water desensitizes the main charge and renders it harmless. It is asserted that, for an explosive charge of up to 10 pounds under a hydrostatic head of about 50 feet, the period of desensitization is 2 to 16 hours.

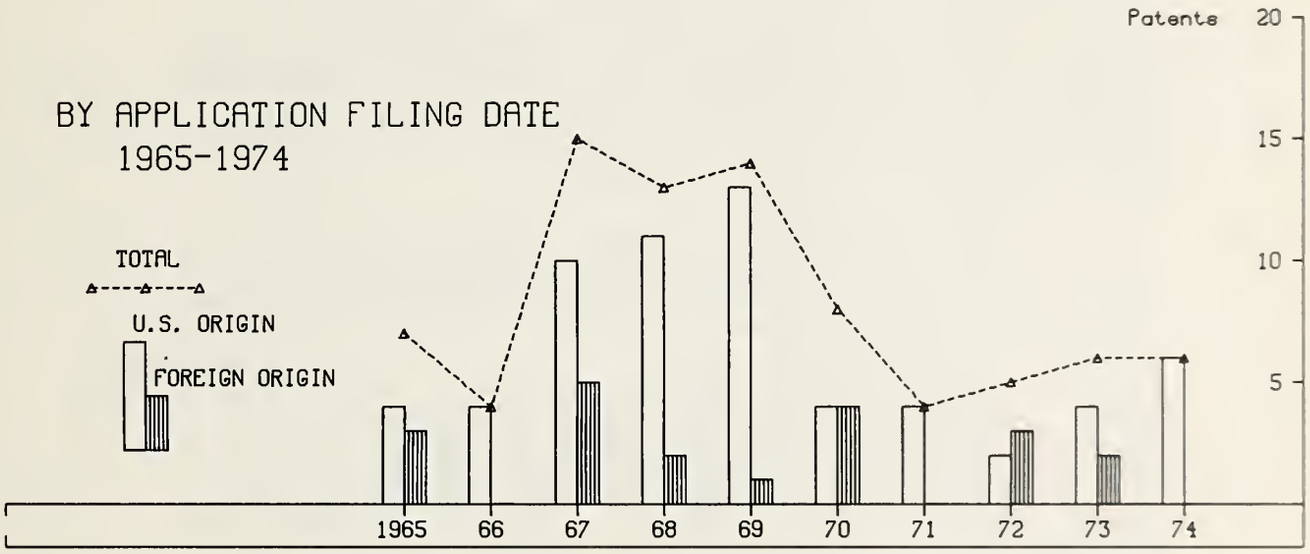
3,939,941 - Fuse Cord (Steele, Imperial Chemical Industries Limited) - Discloses a fuse cord having an external surface with alternating longitudinal ribs and semicircularly curved flutes, for enhanced abrasion resistance, when used in seismic exploration. The fuse cord has a central core of powdered explosive (PETN) which is enclosed in a plastic tube which in turn is covered with two spun layers of yarn or tape. An extruded ribbed sheath of waterproof thermoplastic (polyvinyl chloride) provides the outermost cover.

3,912,041 - Water-Operated Cartridge Launcher (Slaven et al, Hercules Incorporated) - Discloses a water operated explosive cartridge launcher for use in offshore seismic exploration having an injection system which prevents air from mixing with the cartridge propelling stream. The cartridge injection system has a cartridge launching plug that is rotatably mounted within a cylindrical bore which carries the water. A barrel, extending out from the plug, which is sealed off from the atmosphere and from the water flow prior to reaching either its loading or unloading position is used for loading the cartridges. A bypass pipe is connected in parallel with the water passageway to maintain uninterrupted water flow in the system.

3,908,789 - Methods For Generating And Shaping A Seismic Energy Pulse (Itria, Texaco Inc.) - Discloses the use of a vertical, straight, explosive material, suspended under water by a float, to generate and shape seismic energy pulses. A first downwardly propagating compressional energy pulse is generated by initiating detonation of the upper end of the explosive while a second upwardly propagating rarefractional seismic pulse is generated by initiating detonation of explosive material at a position intermediate the ends of the explosive. Variations in the length of the charge and the position of the ignition points shape the energy pulses. It is asserted that the amplitude of the secondary bubbles and time duration are attenuated by this process.

# PATENT ACTIVITY




## DISTRIBUTION OF PATENTS IN AREA OF INTEREST

| | BY PATENT GRANT DATE | | | | | | | | | | TOTAL | BY PATENT APPLICATION FILING DATE | | | | | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1967 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 67-76 | 1965 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 65-74 |
| TOTAL PATENTS | 3 | 12 | 10 | 14 | 12 | 5 | 7 | 7 | 7 | 10 | 87 | 7 | 4 | 15 | 13 | 14 | 8 | 4 | 5 | 6 | 6 | 82 |
| UNITED STATES | 1 | 10 | 8 | 9 | 11 | 5 | 4 | 4 | 6 | 8 | 66 | 4 | 4 | 10 | 11 | 13 | 4 | 4 | 2 | 4 | 6 | 62 |
| TOTAL FOREIGN | 2 | 2 | 2 | 5 | 1 | | 3 | 3 | 1 | 2 | 21 | 3 | | 5 | 2 | 1 | 4 | | 3 | 2 | | 20 |
| FRANCE | 1 | 1 | 1 | 3 | | | 1 | 3 | | 1 | 11 | 2 | | 2 | 1 | 1 | 1 | | 2 | 1 | | 10 |
| UNITED KINGDOM | | | | 2 | 1 | | 2 | | | 1 | 6 | | | 1 | 1 | | 3 | | 1 | | | 6 |
| U.S.S.R. | | 1 | 1 | | | | | | | | 2 | | | 2 | | | | | | | | 2 |
| JAPAN | | | | | | | | | 1 | | 1 | | | | | | | | | 1 | | 1 |
| CANADA | 1 | | | | | | | | | | 1 | 1 | | | | | | | | | | 1 |

## IMPLOSIVE SEISMIC WAVE GENERATORS

Shock wave generators which operate by causing the ambient liquid which surrounds the generator to implode. The implosions are induced either by mechanical movement of the generator or by collapse of a gaseous bubble. These sources are primarily used in offshore seismic prospecting. (Class 181 and Class 340, selected patents)

Activity Indices (1974-1976)

| | | | |
|---|---|---|---|
| Growth (10 year base) | 52.6% | Corporate Owned | 60.0% |
| Foreign Share | 40.0% | Government Owned | 0.0% |

Recent Activity

Recent patent activity focuses on the use of steam or rapid piston movement to produce low pressure areas which will collapse under hydrostatic pressure. The systems are designed for high peak pressure pulse amplitudes and pulses having little or no secondary oscillatory pulses. Patents issued since September of 1974 include:

3,997,022 - Device For Generating Acoustic Waves By Implosion (Cholet, Institut Francais Du Petrole, des Carburants et Lubrifiants et Entreprise de Recherches et d'Activities Petrolieres Elf) - Discloses a marine cylindrical imploder which utilizes two hydraulically driven in-line pistons. The rapid movement of the pistons produces a volume variation in the imploder. Acoustic waves are generated by an implosion which is produced due to the rapid total displaced volume variation of the cylinder and concomitantly, of the surrounding liquid medium.

3,952,833 - Method And Apparatus For Generating Pressure Waves In Water By Implosion (Reed et al, Atlantic Richfield Company) - Discloses a gas exploder which produces imploding cavitation vapor bubbles by rapid movement of a base plate. The exploder comprises a piston chamber within a closed upright cylindrical housing which is supported beneath a water surface by a floating platform. Explosions within the chamber lift the piston to compress an air spring within the housing and thereby transmit a lifting force to the housing. As the housing is lifted a cavitation vapor bubble is created along the undersurface of the base plate.

3,944,019 - Deep Water Sound Imploder (Pauletich) - Discloses an underwater sound imploder consisting of three main units, a boiler, a heat shield and a bell shaped sonic section. Successive sonic impulses are produced by bubbles of steam released into water which is contained within the imploder. The steam bubbles expand until the pressure of the ambient water causes them to burst, thereby causing the imploder to vibrate and produce sonic waves.

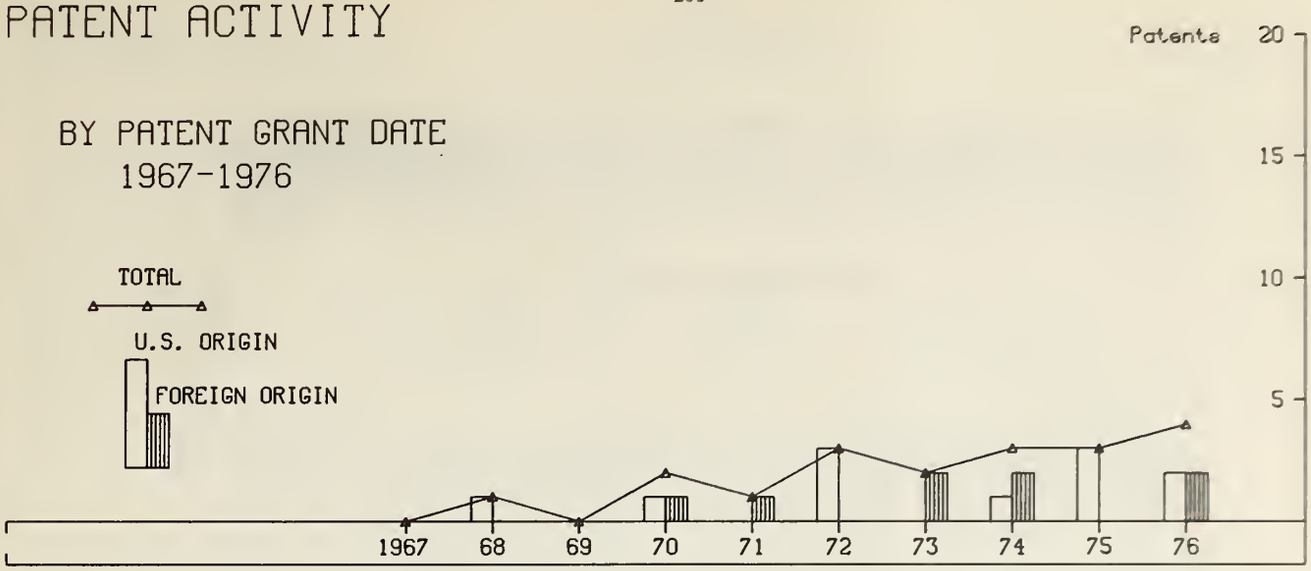
3,919,684 - Underwater Seismic Source And Method (Reed, Atlantic Richfield Company) - Discloses a torpedo shaped underwater seismic implosive wave source which consists of a main body section and a separable forward nose section. An axial connecting rod joins the nose section to a piston which is slidable along part of the main body section. Ignition of an explosive gas mixture in front of the piston rapidly drives the piston and the main body section in opposite directions, thereby creating a low pressure bubble of condensable water vapor. It is asserted that the implosion of this bubble generates a singular seismic pulse having a peak pressure on the order of $10^4$ atmospheres.

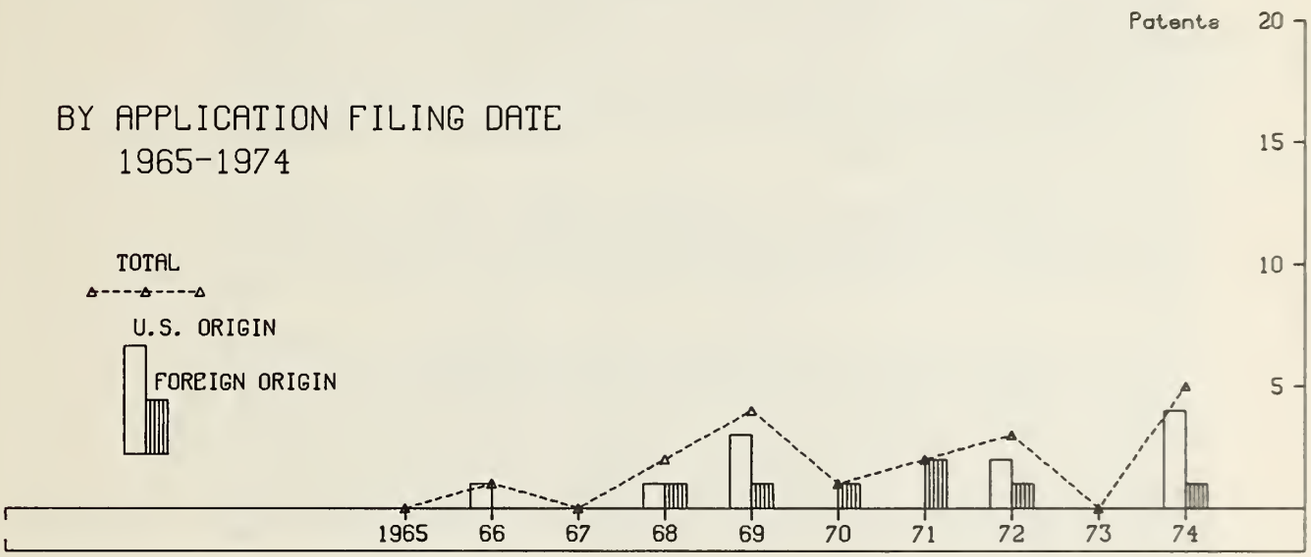
3,912,042 - Steam Imploder (Pauletich) - Discloses a shallow water imploder which uses either remotely generated steam or gases (oxygen and acetylene), which on mixing burn with a heat output high enough to vaporize nearby water. The steam from an outside steam generator, expands within the imploder's outer shield until from hydrostatic pressures cause an implosion.

3,858,171 - Electric Sonic Imploder (Pauletich) - Discloses an imploder which produces steam bubbles in the surrounding water environment by passing high amperage current through triangular shaped conductors. The conductors become red hot, producing steam bubbles in the water which expand between baffle plates until they abruptly collapse, thus causing an implosion.

3,833,087 - Device For Generating Acoustic Waves By Implosion (Cholet, Institut Francais du Petrole, des Carburants et Lubrifiants) - Discloses an imploder having two stationary cylinders and two slideable interconnected pistons, each mounted in a separate cylinder. When a piston is disengaged from a closed position in a cylinder, the surrounding water abruptly fills up the free space of the cylinder, thereby producing an implosion which generates acoustic waves.

# PATENT ACTIVITY




## DISTRIBUTION OF PATENTS IN AREA OF INTEREST

| | BY PATENT GRANT DATE | | | | | | | | | | TOTAL | BY PATENT APPLICATION FILING DATE | | | | | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1967 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 67-76 | 1965 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 65-74 |
| TOTAL PATENTS | | 1 | | 2 | 1 | 3 | 2 | 3 | 3 | 4 | 19 | | 1 | | 2 | 4 | 1 | 2 | 3 | | 5 | 18 |
| UNITED STATES | | 1 | | 1 | | 3 | | 1 | 3 | 2 | 11 | | 1 | | 1 | 3 | | | 3 | | 4 | 11 |
| TOTAL FOREIGN | | | | 1 | 1 | | 2 | 2 | | 2 | 8 | | | | 1 | 1 | 1 | 2 | 1 | | 1 | 7 |
| FRANCE | | | | 1 | 1 | | 2 | 2 | | 2 | 8 | | | | 1 | 1 | 1 | 2 | 1 | | 1 | 7 |

## GAS EXPLODERS

Seismic wave generators in which gaseous fuel-oxidant mixtures are rapidly burned to provide compressional waves for geophysical exploration. Typically, the explosions occur either outside the exploder apparatus and provide direct contact between the shock waves caused by the explosion and the ground, or, inside the exploder, where the shock waves are transmitted outwardly by pistons driven by the explosion. (Selected patents from Class 181 and Class 340).

Activity Indices (1974-1976)

| | | | |
|---|---|---|---|
| Growth (10 year base) | 20.4% | Corporate Owned | 79.0% |
| Foreign Share | 5.3% | Government Owned | 5.3% |

Recent Activity

Recent patent activity has been directed towards minimizing rebound created noise by guiding land gas exploders in both rise and descent and, in addition, cushioning the descent. Activity has also been directed to providing better acoustic wave coupling between the gas exploders and the ground strata to be explored by sealing the explosive section of the exploder in the ground. Patents issued since April 1976 include:

4,026,382 - Repetitive Detonation Seismic Surveying Method And Apparatus (Field et al, Daniel Silverman) - Discloses a gas exploder for use in land prospecting, which uses a long (5 to 8 feet), slender (.25 inch), heavy-walled (O.D. of 0.54 inches) pipe which is open at the bottom end and is driven into the earth. Oxgyen and a combustible gas (preferably acetylene) are passed through the pipe into the voids and fissures in the shallow sediments of the earth. A spark plug at the top of the pipe detonates the gas mixture providing an explosion and concomitantly, seismic waves in the ground. As the explosion opens up ground fissures and provides a subsequent larger void space, the pipe is pressed further into the ground and the process is repeated until the desired seismic wave intensity is reached.

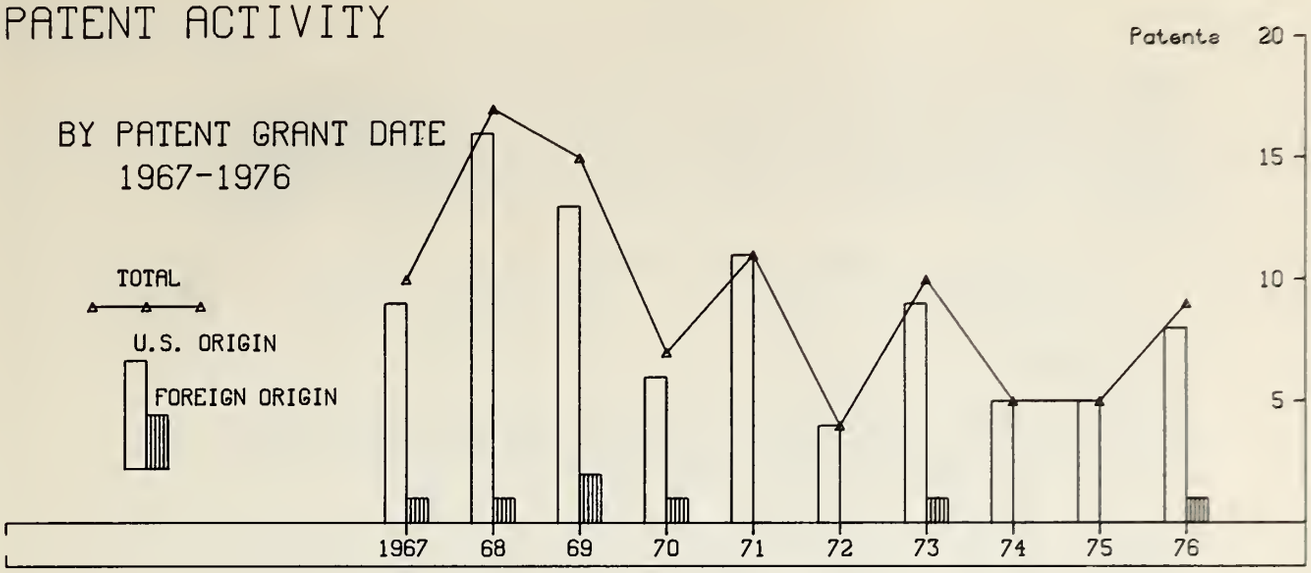
4,016,952 - Marine Gas Exploder (Reed et al, Atlantic Richfield Company) - Discloses a gas exploder device containing a pair of dish shaped plates connected to combustion chamber pistons for use in offshore geophysical prospecting, which produces seismic waves by cavitation. Combustion within the piston chambers accelerates the plates through ambient water, producing cavitation bubbles which collapse and generate seismic waves.

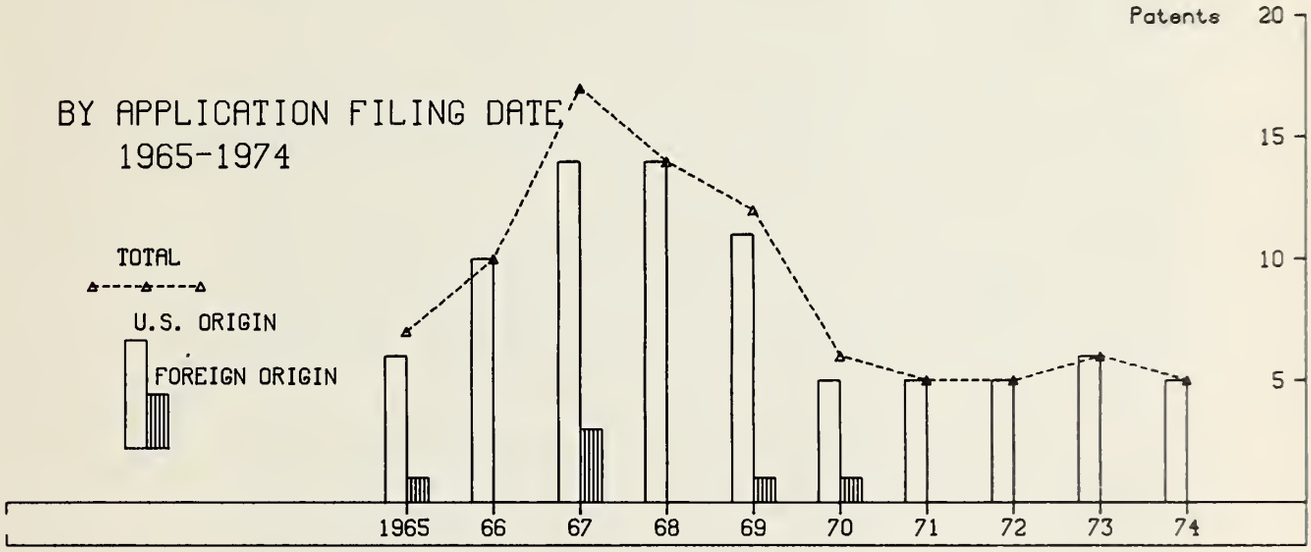
4,007,803 - Expanding Detonation Chamber Multi - Shot Gas Exploder (Airhart, Atlantic Richfield Company) - Discloses a truck transportable gas exploding seismic wave generator for land prospecting containing an elongated cylinder with multiple, sequential, vertically spaced gas inlets mounted on a base, and containing a massive free piston. An explosive gas mixture is initially detonated at the bottom of the cylinder to drive the piston upward, sequentially exposing the gas inlets through which the supply of gas is replenished causing additional detonations to develope. After rising to the top of the cylinder the piston falls, cushioned by the burned gasses, to its lowest limiting position. Each detonation sends shock waves to the base, which generate the acoustical pulses.

3,981,379 - Device For Emitting Mechanical Waves (Sayous, Societe Nationale des Petroles d'Aquitaine) - Discloses a gas exploder particularly adapted for seismic exploration use in shallow water regions (lagoons, swamps, ponds, etc.). A differential piston is mounted in a cylinder which serves as both the mobile wall of a pneumatic chamber and the mobile wall of the gas combustion chamber. The pneumatic chamber provides compressed air to push the piston onto a valve and closes the combustion chamber. The fuel-oxidant gases in the combustion chamber are then ignited to drive the piston upward and create seismic waves.

3,976,161 - Power Auger Seismic Source (Carman, Amoco Production Company) - Discloses a method of generating seismic waves in the earth by detonating an explosive gas mixture in an earth cavity. The cavity is formed by driving a short hollow earth auger into the ground in a manner which leaves most of the augered earth in the hole surrounding the auger shaft, and then pulling the auger upwardly to lift, compress and pack the earth around the auger shaft to seal the cavity. An explosive oxygen-propane gas mixture is introduced into the cavity through the hollow auger shaft and detonated to create seismic waves. After completion of multiple gas fills and detonations the auger is reversed and withdrawn.

# PATENT ACTIVITY




## DISTRIBUTION OF PATENTS IN AREA OF INTEREST

| | BY PATENT GRANT DATE | | | | | | | | | | TOTAL | BY PATENT APPLICATION FILING DATE | | | | | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1967 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 67-76 | 1965 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 65-74 |
| TOTAL PATENTS | 10 | 17 | 15 | 7 | 11 | 4 | 10 | 5 | 5 | 9 | 93 | 7 | 10 | 17 | 14 | 12 | 6 | 5 | 5 | 6 | 5 | 87 |
| UNITED STATES | 9 | 16 | 13 | 6 | 11 | 4 | 9 | 5 | 5 | 8 | 86 | 6 | 10 | 14 | 14 | 11 | 5 | 5 | 5 | 6 | 5 | 81 |
| TOTAL FOREIGN | 1 | 1 | 2 | 1 | | | 1 | | | 1 | 7 | 1 | | 3 | | 1 | 1 | | | | | 6 |
| FRANCE | | | 1 | 1 | | | 1 | | | 1 | 4 | | | 1 | | 1 | 1 | | | | | 3 |
| U.S.S.R. | | 1 | 1 | | | | | | | | 2 | | | 2 | | | | | | | | 2 |
| CANADA | 1 | | | | | | | | | | 1 | 1 | | | | | | | | | | 1 |

## MISCELLANEOUS LAND SEISMIC WAVE GENERATORS

Those seismic wave generators which are used in geophysical exploration on the earth's surface and which do not operate in a vibrator mode and are not powered by solid explosives or by compressed air. Various types of generators exist in this category and no single system is typical of the area. However, electromagnetic generators and the use of heavy weights to impact on the earth comprise the major part of the generators patented in the last 10 years. (Selected patents from Class 181 and Class 340).

Activity Indices (1974-1976)

| | | | |
|---|---|---|---|
| Growth (10 year base) | 44.0% | Corporate Owned | 73.0% |
| Foreign Share | 0.0% | Government Owned | 0.0% |

Recent Activity

Recent patent activity has been directed towards the use of seismic generators having modulation control of the wave output. The controls operate on the intervals between the seismic pulses, the output frequency of the pulses and the shaping of the wave fronts of the pulses. Patents issued since July 1975 include:

4,020,919 - Seismic Source With No Reaction Mass (Broding, Standard Oil Company, Indiana) - Discloses a seismic signal generator which operates through the use of a modulated vacuum over the surface of the earth. A chamber with an air exhaust and a vent is mounted on an inflated compliant vibration isolator (conveniently this could be an inflated auto tire tube) and degassed to provide an internal low pressure area. By modulating a flow control valve in the air vent both the coupling between the signal generator and the force applied to the earth's surface are varied.

4,011,924 - Device For Producing Mechanical Waves (Barbier, Societe National des Petroles d'Aquitaine) - Discloses the use of a percussion mass for striking the ground with intermittent contact at a frequency of between 0.5Hz and 100Hz in order to produce seismic waves for shallow terrestrial seismology. A rotary internal combustion motor drives the percussion mass and the frequency of impact is varied by adjusting the motor's throttle lever and transmission cable.

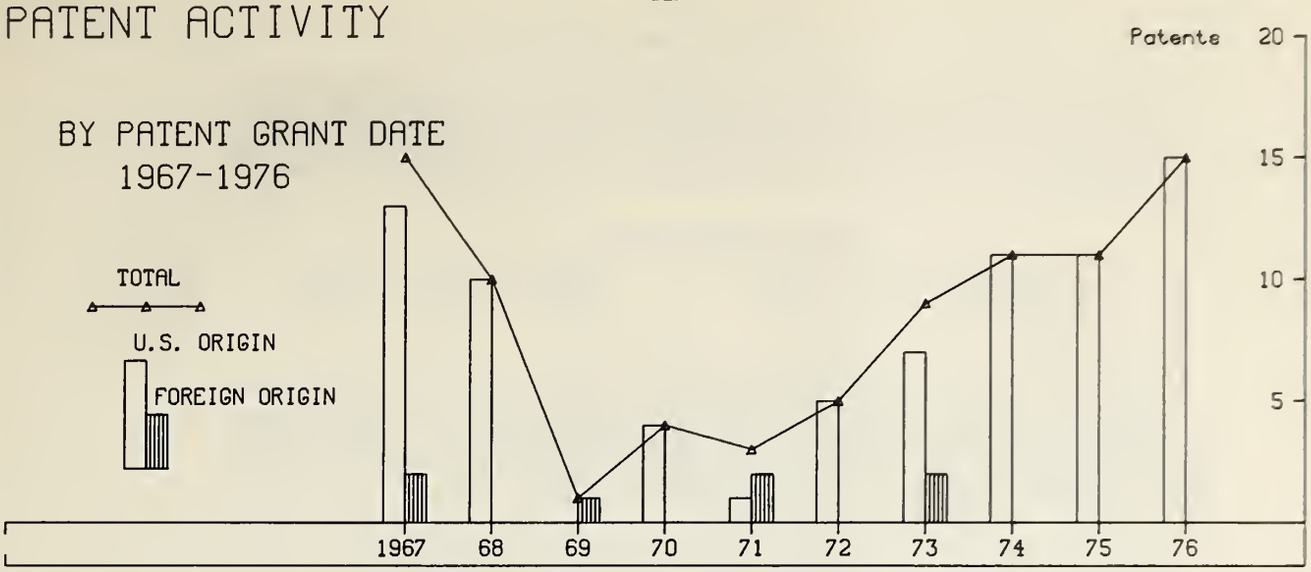
3,942,606 - Method Of Land Seismic Exploration Using Flexible Tubes (Dick, Western Geophysial Company of America) - Discloses the use of elongated flexible wall tubes which serve a dual purpose in seismic exploration. First, they are connected to a pressure transducer which monitors seismic waves which are reflected from substrata into the tubes. Second, the tubes are connected to a detonator which creates a linear seismic energy source by igniting a liquid explosive contained within the tube. During seismic prospecting the tubes are consecutively coupled to detectors to detect the explosion of other tubes, and then exploded sequentially.

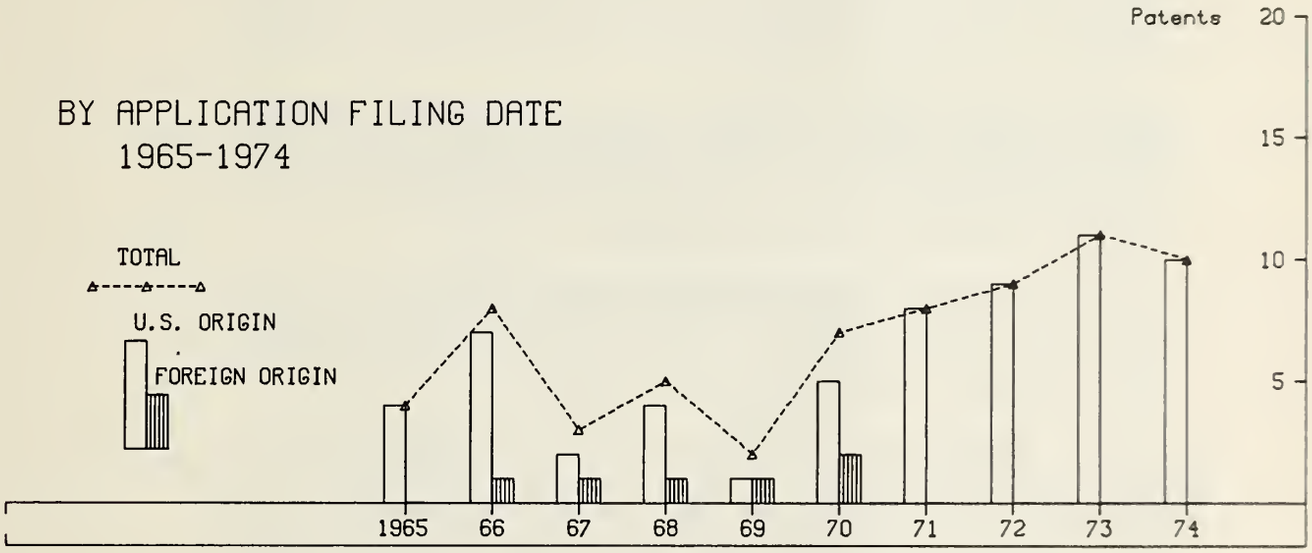
3,974,476 - Highly Directional Acoustic Source For Use In Borehole Surveys (Cowles, Shell Oil Company) - Discloses a borehole acoustic wave generator having an acoustic transducer mounted at one end of a liquid filled tubular housing and an acoustic reflector, which will direct the acoustic waves 90° to the longitudinal axis of the housing at the other end. Two frequencies (4999.5 kHz and 5000.5kHz) for energizing the transducer are supplied by separate oscillating circuits to produce by parametric generation, a directional acoustic pulse of the difference of the two frequencies (1 kHz).

3,938,072 - Resonance Earth Structure Logging (Baird et al) - Discloses a seismic wave exploration system which uses a collimated energy beam and a seismic wave generator that is also the receiving tranducer. A simulated borehole is created through a steel base plate (16" diameter, 4" thick) which is powered by 20 driving piezoelectric crystals, each rated at 100 watts, and arranged in a circle on the upper surface of the plate. When the piezoelectric crystals are energized a collimated acoustical wave is transmitted into the earth until a response is established in the driving transducers. The resonance conditions are indicative of a subsurface strata structure and are monitored by observing and recording the resonance effect on the power supply to the drivers.

3,896,413 Permeability Logging Method Using Apparatus Comprising Current Electrodes Between Electromagnets, Current Electrode On The Surface And Acoustic Listening Devices To Detect Pressure Related Noise (Dowling et al, Texaco Inc.)- Discloses an electromagnetic acoustic wave generator for measuring porosity in earth formations adjacent a borehole. The generator consists of a sonde having dual magnetic poles (north and south) between which a currect electrode is situated. The fields which are generated by the magnet and electrode create localized increases in pressure in the fluids which are located in the interstices of the formation, thus causing the fluids to flow. This fluid flow creates sound waves by fluid interaction with capillary side walls and surrounding particles which define the capillaries holding the fluid. The noise level and frequency content of the acoustic waves generated are indicative of the formation's permeability.

# PATENT ACTIVITY




## DISTRIBUTION OF PATENTS IN AREA OF INTEREST

| | BY PATENT GRANT DATE | | | | | | | | | | TOTAL | BY PATENT APPLICATION FILING DATE | | | | | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1967 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 67-76 | 1965 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 65-74 |
| TOTAL PATENTS | 15 | 10 | 1 | 4 | 3 | 5 | 9 | 11 | 11 | 15 | 84 | 4 | 8 | 3 | 5 | 2 | 7 | 8 | 9 | 11 | 10 | 67 |
| UNITED STATES | 13 | 10 | | 4 | 1 | 5 | 7 | 11 | 11 | 15 | 77 | 4 | 7 | 2 | 4 | 1 | 5 | 8 | 9 | 11 | 10 | 61 |
| TOTAL FOREIGN | 2 | | 1 | | 2 | | 2 | | | | 7 | | 1 | 1 | 1 | 1 | 2 | | | | | 6 |
| FRANCE | 1 | | | | | | 1 | | | | 2 | | | | | | 1 | | | | | 1 |
| GERMANY | 1 | | 1 | | | | | | | | 2 | | 1 | 1 | | | | | | | | 2 |
| CANADA | | | | | | | 1 | | | | 1 | | | | | | 1 | | | | | 1 |
| UNITED KINGDOM | | | | | 1 | | | | | | 1 | | | | | 1 | | | | | | 1 |
| U.S.S.R. | | | | | 1 | | | | | | 1 | | | | 1 | | | | | | | 1 |

## MISCELLANEOUS MARINE SEISMIC WAVE GENERATORS

Underwater generators of seismic waves which are used in seismic exploration and which operate by physical principles other than those of vibrators, implosives, solid or gas explosives and air guns. These generators cover a broad spectrum of acoustic wave generation, such as by mechanial impact, electromagnetic, piezoelectric, mags netostrictive, water hammer and laser heating. (Selected patents from Class 181 and Class 340).

Activity Indices (1974-1976)

| | | | |
|---|---|---|---|
| Growth (10 year base) | 17.9% | Corporate Owned | 64.3% |
| Foreign Share | 21.4% | Government Owned | 28.6% |

Recent Activity

Recent patent activity has been directed towards directional seismic wave generators which can be used to mitigate the effect of received signal noise. Typical systems utilize plural electromagnetic drivers with lobe design to achieve the desired directivity and passbands. Patent activity has also been directed to the use of optical frequency electromagnetic wave sources, particularly laser generated light for seismic wave generation. Patents issued since October 1975 include:

4,006,795 - Means For Seismic Prospecting From Bulk Liquid Carriers (Anstey, Seiscom Delta Inc.) - Discloses a broad seismic wave source adopted for reconnaissance and use in oil tankers of the 50,000-100,000 ton class. A motor driven shaft drives a group of weights against an anvil, acting as a flail, to transmit the shock waves to the plates of the ship. The bandwidth of the source is modulated by changing either the material of the weight, the material of the anvil, or the mass and rigidity of the anvilplate combination.

3,993,973 - Underwater Transient Sound Generator Having Pressure Compensating Fillet (Hutchins et al, Huntec (70) Limited) - Discloses a transient sound generator for producing uniform pulses from a piston plate outwardly repelled into the water by eddy currents induced in the plate by an electromagnetic coil. The pressure at the rear face of the piston, tracks the pressure at the piston front face through the use of a rear compressable air volume which is connected by a bleeder aperture to a non-compressable air volume at the rear face of the piston.

3,992,693 - Underwater Transducer And Projector Therefor (Martin et al, The Bendix Corporation) - Discloses a ring shaped seismic wave generator formed of plural segments of an alternately placed active material (e.g. barium titanate) and an inactive material (e.g. alumina). The velocity of sound in the inactive material is different than that of the active material. The generator rings are positioned axially along a central support tube and are separated by neoprene spacers.

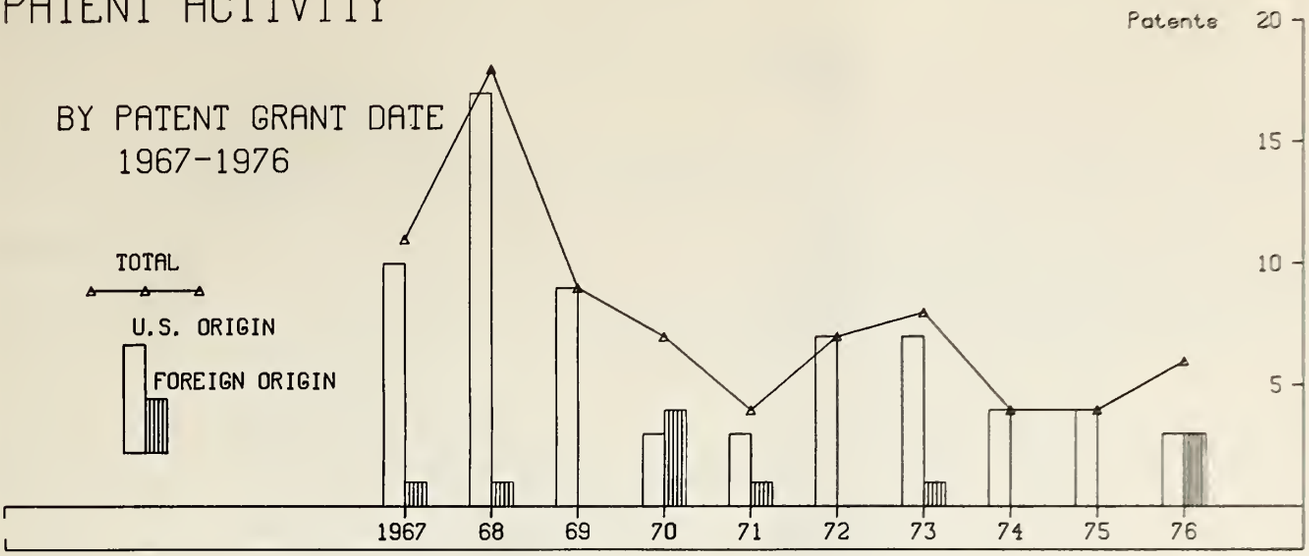
3,990,034 - Towable VLF Sonar Projector (Abbott, The United States of America as represented by The Secretary of The Navy) - Discloses a cylindrical, elongated, towed, transverse variable reluctance acoustic energy transducer having an axial tunnel running its length through which water flows for cooling the transducer. The transducer operates in a magnetomotive mode wherein magnetically interacting fields of flux, generated by alternating currents and direct currents, cause radial displacement of projecting surfaces. The magnetic poles consist of continuously extending helical strips.

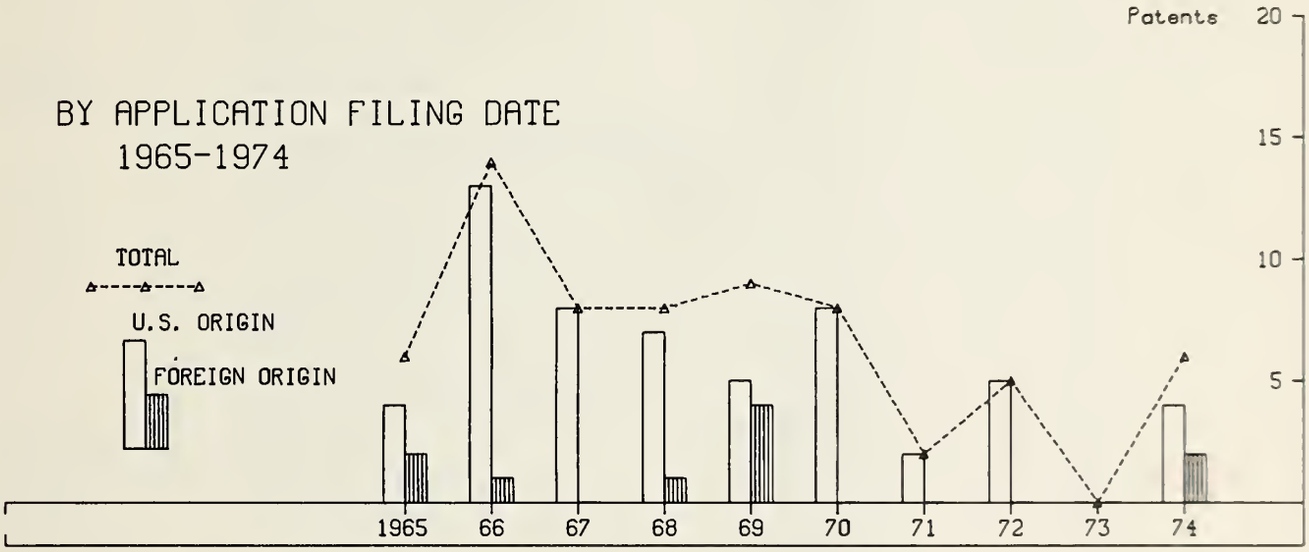
3,949,831 - Device For Generating Acoustic Waves In A Liquid Medium (Cassand et al, Institut Francaise de Petrole, des Carburants et Librifiants) - Discloses a seismic wave generator which operates by abruptly braking a mass of water in motion. A hollow enclosure is provided with two liquid containing hollow sections interconnected by a narrow passage. The seal between the two sections is intermittantly closed so as to create, by hydraulic or electromagnetic drive, a fluid induced pressure differential between the sections. The resultant water hammer effect creates acoustic waves which are used for seismic exploration.

3,946,831 - Acoustic Transmitter (Bouyoucos, Hydroacoustics Inc.) - Discloses a directional acoustic wave transmitter system which contains a seismic wave generator and a wave transmission line. Ports are provided along the length of the line and are surrounded by antiresonant coupler sections which present a high acoustic driving point impedance to their respective ports. It is asserted that the ports evenly partition the seismic waves produced by the generator and concomitantly define an array of equal strength directional radiators.

3,913,060 - Thermooptic Sonar System (Westervelt et al, The United States of America As Represented By The Secretary of Navy) - Discloses a system of developing coherent acoustic beams in fluid mediums. The beam of a high power laser is directed by a beam splitter, in two separate directions in fluid, and is absorbed by the fluid. The fluid converts the absorbed optical energy to acoustical energy by expansion along the absorption path so that the resultant acoustic beams are perpendicular to the paths of the laser beams.

# PATENT ACTIVITY




## DISTRIBUTION OF PATENTS IN AREA OF INTEREST

| | BY PATENT GRANT DATE | | | | | | | | | | TOTAL | BY PATENT APPLICATION FILING DATE | | | | | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1967 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 67-76 | 1965 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 65-74 |
| TOTAL PATENTS | 11 | 18 | 9 | 7 | 4 | 7 | 8 | 4 | 4 | 6 | 78 | 6 | 14 | 8 | 8 | 9 | 8 | 2 | 5 | | 6 | 66 |
| UNITED STATES | 10 | 17 | 9 | 3 | 3 | 7 | 7 | 4 | 4 | 3 | 67 | 4 | 13 | 8 | 7 | 5 | 8 | 2 | 5 | | 4 | 56 |
| TOTAL FOREIGN | 1 | 1 | | 4 | 1 | | 1 | | | 3 | 11 | 2 | 1 | | 1 | 4 | | | | | 2 | 10 |
| FRANCE | 1 | 1 | | 2 | | | 1 | | | 2 | 7 | 1 | 1 | | 1 | 2 | | | | | 2 | 7 |
| UNITED KINGDOM | | | | 1 | 1 | | | | | | 2 | | | | | 2 | | | | | | 2 |
| CANADA | | | | | | | | | | 1 | 1 | | | | | | | | | | | |
| JAPAN | | | | 1 | | | | | | | 1 | 1 | | | | | | | | | | 1 |

# APPENDIX A

## SECTION I DATA TABLES

# PATENT

*[Th*
*in*

| SIC CATEGORY | PRODUCT FIELD | NY, BEL LL IC | | FRANCE | | U.S.S.R. | | ALL OTHERS* | |
|---|---|---|---|---|---|---|---|---|---|
| | | To U.S | m U.S. | To U.S. | From U.S. | To U.S. | From U.S. | To U.S. | From U.S. |
| 20 | Food and Kindred Products | 2 | 163 | 22 | 149 | 2 | 3 | 36 | 145 |
| 22 | Textile Mill Products | – | 111 | 16 | 91 | – | – | 18 | 63 |
| 28 | Chemicals and Allied Products | 45 | ,287 | 419 | 2,167 | 17 | 51 | 417 | 1,789 |
| 281, 282, 284–289 | . Chemicals, Except Drugs & Medicines | 45 | ,259 | 413 | 2,143 | 17 | 51 | 413 | 1,764 |
| 281, 286 | . . Basic Industrial Inorganic & Organic Chemistry | 36 | .368 | 241 | 1,319 | 8 | 35 | 228 | 1,126 |
| 281 | . . . Industrial Inorganic Chemistry | 10 | 265 | 57 | 232 | 1 | 1 | 52 | 149 |
| 286 | . . . Industrial Organic Chemistry | 28 | ,171 | 203 | 1,142 | 7 | 35 | 192 | 1,014 |
| 282 | . . Plastics Materials & Synthetic Resins | 9 | 521 | 88 | 489 | 4 | 2 | 93 | 304 |
| 287 | . . Agricultural Chemicals | 5 | 273 | 81 | 268 | 3 | 14 | 67 | 318 |
| 284, 285, 289 | . . All Other Chemicals | 1 | 177 | 25 | 151 | 2 | 1 | 46 | 106 |
| 284 | . . . Soap, Detergents and Cleaning Preparations, Perfumes, Cosmetics & Other Toilet Preparations | – | 77 | 8 | 64 | 1 | – | 32 | 42 |
| 285 | . . . Paints, Varnishes, Lacquers, Enamels, and Allied Products | 1 | 21 | 1 | 19 | – | – | – | 20 |
| 289 | . . . Miscellaneous Chemical Products | – | 110 | 20 | 92 | 1 | 1 | 20 | 47 |
| 283 | . Drugs and Medicines | 7 | 291 | 90 | 288 | 6 | 11 | 79 | 331 |
| 13, 29 | Petroleum & Natural Gas Extraction & Petroleum Refining | 1 | 146 | 16 | 113 | 1 | – | 10 | 84 |
| 30 | Rubber & Miscellaneous Plastics Products | 10 | 518 | 110 | 448 | – | 4 | 111 | 299 |
| 32 | Stone, Clay, Glass and Concrete Products | 6 | 253 | 46 | 228 | 1 | – | 57 | 167 |
| 33, 3462, 3463 | Primary Metals | 14 | 178 | 29 | 158 | 4 | – | 70 | 154 |
| 331, 332, 3399, 3462 | . Primary Ferrous Products | 11 | 141 | 23 | 124 | 2 | – | 59 | 127 |
| 333–336, 339 (except 3399), 3463 | . Primary & Secondary Non-Ferrous Metals | 5 | 103 | 14 | 89 | 4 | – | 39 | 74 |
| 34 (except 3462, 3463, 348) | Fabricated Metal Products | 20 | ,040 | 205 | 829 | 2 | 1 | 282 | 671 |
| 35 | Machinery, Except Electrical | 53 | ,753 | 663 | 2,224 | 41 | 9 | 888 | 1,742 |
| 351 | . Engines & Turbines | 2 | 227 | 68 | 174 | 2 | – | 46 | 152 |
| 352 | . Farm & Garden Machinery & Equipment | 1 | 211 | 57 | 176 | 3 | – | 87 | 226 |
| 353 | . Construction, Mining & Material Handling Machinery & Equipment | 3 | 328 | 122 | 303 | 10 | – | 166 | 335 |
| 354 | . Metal Working Machinery & Equipment | 14 | 255 | 59 | 193 | 6 | 2 | 77 | 153 |
| 357 | . Office Computing & Accounting Machines | 5 | 447 | 63 | 372 | 2 | 2 | 63 | 214 |
| 355, 356, 358, 359 | . Other Machinery, Except Electrical | 33 | ,727 | 406 | 1,368 | 26 | 7 | 609 | 1,102 |
| 355 | . . Special Industry Machinery, Except Metal Working Machinery | 21 | 791 | 192 | 624 | 10 | 4 | 297 | 423 |
| 356 | . . General Industrial Machinery & Equipment | 11 | 822 | 190 | 652 | 15 | 4 | 268 | 605 |
| 358 | . . Refrigeration & Service Industry Machinery | 1 | 187 | 44 | 140 | 2 | – | 65 | 138 |
| 359 | . . Miscellaneous Machinery, Except Electrical | 3 | 146 | 30 | 118 | 5 | – | 49 | 120 |
| 36, 3825 | Electrical and Electronic Machinery, Equipment and Supplies | 21 | ,757 | 379 | 1,458 | 11 | 5 | 280 | 930 |
| 361–364, 369, 3825 | . Electrical Equipment, Except Communication Equipment | 10 | 826 | 184 | 675 | 9 | 2 | 171 | 454 |
| 361, 3825 | . . Electrical Transmission & Distribution Equipment | 1 | 228 | 63 | 187 | 1 | – | 43 | 116 |
| 362 | . . Electrical Industrial Apparatus | 2 | 225 | 48 | 190 | 7 | – | 42 | 123 |

* *All other countries covered by the Derwent da*
*Section 1) except Japan, the data for Japan b*

# APPENDIX A

## SECTION I DATA TABLES

## PATENT BALANCE BY PRODUCT FIELD — U.S. vs. SELECTED FOREIGN COUNTRIES

*[The table below and the following page show the international exchange of patents on all technologies patented in the U.S. in 1975. The data are distributed by Standard Industrial Classification Product Field.]*

| SIC CATEGORY | PRODUCT FIELD | BELGIUM | | CANADA | | SWITZERLAND | | UNITED KINGDOM | | SOUTH AFRICA | | NETHERLANDS | | GERMAN DEMOCRATIC REPUBLIC | | GERMANY, FEDERAL REPUBLIC | | FRANCE | | U.S.S.R. | | ALL OTHERS* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | To U.S. | From U.S. | To U.S. | From U.S. | To U.S. | From U.S. | To U.S. | From U.S. | To U.S. | From U.S. | To U.S. | From U.S. | To U.S. | From U.S. | To U.S. | From U.S. | To U.S. | From U.S. | To U.S. | From U.S. | To U.S. | From U.S. |
| 20 | Food and Kindred Products | 2 | 95 | – | 86 | 19 | 27 | 58 | 145 | 1 | 48 | 15 | 108 | 2 | 17 | 47 | 163 | 22 | 149 | 2 | 3 | 36 | 145 |
| 22 | Textile Mill Products | – | 47 | 3 | 50 | 18 | 26 | 51 | 83 | – | 17 | 5 | 54 | – | 4 | 90 | 111 | 16 | 91 | – | – | 18 | 63 |
| 28 | Chemicals and Allied Products | 45 | 1,257 | 41 | 832 | 552 | 484 | 717 | 1,913 | 9 | 768 | 84 | 1,430 | 15 | 236 | 1,433 | 2,287 | 419 | 2,167 | 17 | 51 | 417 | 1,789 |
| 281, 282, 284–289 | . Chemicals, Except Drugs & Medicines | 45 | 1,244 | 41 | 824 | 552 | 477 | 709 | 1,888 | 8 | 758 | 84 | 1,413 | 14 | 233 | 1,422 | 2,259 | 413 | 2,143 | 17 | 51 | 413 | 1,764 |
| 281, 286 | . . Basic Industrial Inorganic & Organic Chemistry | 36 | 768 | 26 | 518 | 432 | 380 | 438 | 1,240 | 7 | 478 | 54 | 904 | 11 | 154 | 942 | 1,368 | 241 | 1,319 | 8 | 35 | 228 | 1,126 |
| 281 | . . . Industrial Inorganic Chemistry | 10 | 124 | 17 | 113 | 11 | 15 | 67 | 207 | 7 | 61 | 12 | 134 | 3 | 16 | 162 | 265 | 57 | 232 | 1 | 1 | 52 | 149 |
| 286 | . . . Industrial Organic Chemistry | 28 | 686 | 13 | 429 | 427 | 375 | 396 | 1,089 | – | 424 | 48 | 810 | 10 | 145 | 839 | 1,171 | 203 | 1,142 | 7 | 35 | 192 | 1,014 |
| 282 | . . Plastics Materials & Synthetic Resins | 9 | 262 | 13 | 130 | 51 | 25 | 116 | 336 | – | 111 | 23 | 300 | 4 | 30 | 288 | 521 | 88 | 489 | 4 | 2 | 93 | 304 |
| 287 | . . Agricultural Chemicals | 5 | 188 | 2 | 127 | 92 | 88 | 124 | 262 | – | 170 | 9 | 187 | 2 | 50 | 181 | 273 | 81 | 268 | 3 | 14 | 67 | 318 |
| 284, 285, 289 | . . All Other Chemicals | 1 | 83 | 1 | 96 | 14 | 19 | 52 | 139 | 1 | 39 | 3 | 91 | – | 5 | 70 | 177 | 25 | 151 | 2 | 1 | 46 | 106 |
| 284 | . . . Soap, Detergents and Cleaning Preparations, Perfumes, Cosmetics & Other Toilet Preparations | – | 35 | – | 44 | 15 | 12 | 22 | 70 | – | 16 | 1 | 41 | – | 4 | 30 | 77 | 8 | 64 | 1 | – | 32 | 42 |
| 285 | . . . Paints, Varnishes, Lacquers, Enamels, and Allied Products | 1 | 11 | – | 8 | 2 | – | 4 | 11 | – | 7 | – | 19 | – | 1 | 6 | 21 | 1 | 19 | – | – | – | 20 |
| 289 | . . . Miscellaneous Chemical Products | – | 51 | 1 | 61 | 3 | 11 | 32 | 78 | 1 | 20 | 4 | 49 | – | – | 42 | 110 | 20 | 92 | 1 | 1 | 20 | 47 |
| 283 | . Drugs and Medicines | 7 | 193 | 1 | 113 | 82 | 96 | 143 | 284 | 1 | 163 | 9 | 189 | 4 | 34 | 194 | 291 | 90 | 288 | 6 | 11 | 79 | 331 |
| 13, 29 | Petroleum & Natural Gas Extraction & Petroleum Refining | 1 | 41 | 5 | 51 | 1 | 5 | 38 | 72 | – | 49 | 3 | 65 | – | 11 | 24 | 146 | 16 | 113 | 1 | – | 10 | 84 |
| 30 | Rubber & Miscellaneous Plastics Products | 10 | 187 | 20 | 308 | 35 | 63 | 187 | 432 | 2 | 127 | 15 | 200 | 1 | 11 | 243 | 518 | 110 | 448 | – | 4 | 111 | 299 |
| 32 | Stone, Clay, Glass and Concrete Products | 6 | 120 | 10 | 166 | 13 | 22 | 102 | 219 | 1 | 59 | 13 | 110 | 2 | 8 | 104 | 253 | 46 | 228 | 1 | – | 57 | 167 |
| 33, 3462, 3463 | Primary Metals | 14 | 85 | 15 | 93 | 6 | 7 | 49 | 136 | 4 | 51 | 10 | 61 | 1 | 9 | 85 | 178 | 29 | 158 | 4 | – | 70 | 154 |
| 331, 332, 3399, 3462 | . Primary Ferrous Products | 11 | 70 | 9 | 80 | 4 | 6 | 34 | 102 | 4 | 45 | 8 | 53 | – | 7 | 64 | 141 | 23 | 124 | 2 | – | 59 | 127 |
| 333–336, 339 (except 3399), 3463 | . Primary & Secondary Non-Ferrous Metals | 5 | 41 | 10 | 40 | 6 | 2 | 31 | 74 | 3 | 23 | 4 | 29 | 1 | 4 | 46 | 103 | 14 | 89 | 4 | – | 39 | 74 |
| 34 (except 3462, 3463, 348) | Fabricated Metal Products | 20 | 297 | 44 | 704 | 98 | 128 | 330 | 772 | 8 | 210 | 51 | 326 | 7 | 22 | 558 | 1,040 | 205 | 829 | 2 | 1 | 282 | 671 |
| 35 | Machinery, Except Electrical | 53 | 714 | 104 | 1,596 | 334 | 263 | 844 | 2,112 | 30 | 468 | 135 | 773 | 31 | 68 | 1,827 | 2,753 | 663 | 2,224 | 41 | 9 | 888 | 1,742 |
| 351 | . Engines & Turbines | 2 | 52 | 7 | 134 | 25 | 19 | 101 | 152 | – | 20 | 8 | 34 | – | 8 | 192 | 227 | 68 | 174 | 2 | – | 46 | 152 |
| 352 | . Farm & Garden Machinery & Equipment | 1 | 56 | 14 | 165 | 13 | 15 | 71 | 143 | 6 | 62 | 23 | 67 | 1 | 6 | 93 | 211 | 57 | 176 | 3 | – | 87 | 226 |
| 353 | . Construction, Mining & Material Handling Machinery & Equipment | 3 | 101 | 26 | 305 | 30 | 22 | 101 | 297 | 8 | 101 | 27 | 97 | – | 8 | 203 | 328 | 122 | 303 | 10 | – | 166 | 335 |
| 354 | . Metal Working Machinery & Equipment | 14 | 56 | 7 | 144 | 30 | 18 | 81 | 199 | 9 | 41 | 6 | 57 | 7 | 10 | 218 | 255 | 59 | 193 | 6 | 2 | 77 | 153 |
| 357 | . Office Computing & Accounting Machines | 5 | 87 | 1 | 150 | 34 | 47 | 85 | 299 | 1 | 24 | 20 | 127 | – | 12 | 138 | 447 | 63 | 372 | 2 | 2 | 63 | 214 |
| 355, 356, 358, 359 | . Other Machinery, Except Electrical | 33 | 471 | 70 | 968 | 242 | 178 | 562 | 1,302 | 18 | 325 | 74 | 519 | 23 | 41 | 1,216 | 1,727 | 406 | 1,368 | 26 | 7 | 609 | 1,102 |
| 355 | . . Special Industry Machinery, Except Metal Working Machinery | 21 | 243 | 32 | 383 | 140 | 97 | 233 | 608 | 5 | 139 | 30 | 271 | 20 | 22 | 616 | 791 | 192 | 624 | 10 | 4 | 297 | 423 |
| 356 | . . General Industrial Machinery & Equipment | 11 | 191 | 34 | 511 | 89 | 63 | 298 | 612 | 11 | 163 | 29 | 214 | 2 | 19 | 522 | 822 | 190 | 652 | 15 | 4 | 268 | 605 |
| 358 | . . Refrigeration & Service Industry Machinery | 1 | 50 | 6 | 120 | 28 | 16 | 54 | 139 | 4 | 39 | 16 | 55 | – | 8 | 116 | 187 | 44 | 140 | 2 | – | 65 | 138 |
| 359 | . . Miscellaneous Machinery, Except Electrical | 3 | 42 | 10 | 74 | 9 | 16 | 36 | 107 | 3 | 27 | 6 | 43 | 1 | 1 | 79 | 146 | 30 | 118 | 5 | – | 49 | 120 |
| 36, 3825 | Electrical and Electronic Machinery, Equipment and Supplies | 21 | 425 | 34 | 765 | 132 | 182 | 487 | 1,112 | 6 | 152 | 203 | 625 | 17 | 42 | 893 | 1,757 | 379 | 1,458 | 11 | 5 | 280 | 930 |
| 361-364, 369, 3825 | . Electrical Equipment, Except Communication Equipment | 10 | 202 | 22 | 401 | 86 | 90 | 242 | 515 | 3 | 96 | 82 | 254 | 13 | 14 | 552 | 826 | 184 | 675 | 9 | 2 | 171 | 454 |
| 361, 3825 | . . Electrical Transmission & Distribution Equipment | 1 | 37 | 5 | 109 | 21 | 19 | 51 | 126 | – | 18 | 21 | 63 | 6 | 3 | 161 | 228 | 63 | 187 | 1 | – | 43 | 116 |
| 362 | . . Electrical Industrial Apparatus | 2 | 61 | 8 | 117 | 30 | 19 | 76 | 155 | 1 | 25 | 19 | 69 | 5 | 2 | 221 | 225 | 48 | 190 | 7 | – | 42 | 123 |

* *All other countries covered by the Derwent data base (see Table 1-1 in Section 1) except Japan, the data for Japan being incomplete.*

## PATENT BALANC

| SIC CATEGORY | PRODUCT FIELD | BELGIU | | FRANCE | | U.S.S.R. | | ALL OTHERS* | |
|---|---|---|---|---|---|---|---|---|---|
| | | To U.S. | Fro | To U.S. | From U.S. | To U.S. | From U.S. | To U.S. | From U.S. |
| 363, 364, 369 | . . Other Electrical Machinery, Equipment & Supplies | 8 | 1 | 98 | 362 | 2 | 2 | 99 | 260 |
| 363 | . . . Household Appliances | 4 | | 18 | 108 | 1 | – | 48 | 77 |
| 364 | . . . Electrical Lighting & Wiring Equipment | 1 | | 26 | 83 | – | 1 | 15 | 44 |
| 369 | . . . Miscellaneous Electrical Machinery, Equipment & Supplies | 3 | | 53 | 170 | 1 | 1 | 36 | 139 |
| 365–367 | . Communication Equipment & Electronic Components | 12 | 2 | 245 | 922 | 6 | 3 | 128 | 548 |
| 365 | . . Radio & Television Receiving Equipment, Except Communication Types | 1 | | 32 | 160 | – | – | 22 | 94 |
| 366–367 | . . Electronic Components & Accessories & Communication Equipment | 12 | 2 | 245 | 915 | 6 | 3 | 126 | 539 |
| 37, 348 | Transportation Equipment | 7 | | 196 | 362 | 2 | 3 | 127 | 314 |
| 371, 373–376, 379 (except 3795) | . Motor Vehicles & Other Transportation | 7 | | 183 | 329 | 1 | 3 | 124 | 298 |
| 371 | . . Motor Vehicles & Motor Vehicles Equipment | 5 | | 110 | 219 | 1 | 3 | 69 | 171 |
| 376 | . . Guided Missiles & Space Vehicles & Parts | – | | 16 | 47 | – | – | 5 | 40 |
| 373–375, 379 (except 3795) | . . Other Transportation Equipment | 1 | | 66 | 114 | – | – | 50 | 122 |
| 373 | . . . Ship & Boat Building & Repairing | – | | 17 | 30 | – | – | 18 | 61 |
| 374 | . . . Railroad Equipment | – | | 40 | 74 | – | – | 22 | 58 |
| 375 | . . . Motorcycles, Bicycles & Parts | – | | 9 | 19 | – | – | 2 | 23 |
| 379 (except 3795) | . . . Miscellaneous Transportation Equipment | 1 | | 40 | 80 | – | – | 27 | 54 |
| 348, 3795 | . . Ordinance Except Missiles | 1 | | 20 | 21 | – | – | 15 | 15 |
| 372 | . Aircraft & Parts | 2 | | 63 | 120 | 2 | – | 31 | 94 |
| 38 (except 3825) | Professional & Scientific Instruments | 11 | 3 | 176 | 894 | 10 | 2 | 250 | 660 |

** All other countries covered by the Derwent*
*Section 1) except Japan, the data for Japa*

## PATENT BALANCE BY PRODUCT FIELD — U.S. vs. SELECTED FOREIGN COUNTRIES (Continued)

| SIC CATEGORY | PRODUCT FIELD | BELGIUM | | CANADA | | SWITZERLAND | | UNITED KINGDOM | | SOUTH AFRICA | | NETHERLANDS | | GERMAN DEMOCRATIC REPUBLIC | | GERMANY, FEDERAL REPUBLIC | | FRANCE | | U.S.S.R. | | ALL OTHERS* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | To U.S. | From U.S. | To U.S. | From U.S. | To U.S. | From U.S. | To U.S. | From U.S. | To U.S. | From U.S. | To U.S. | From U.S. | To U.S. | From U.S. | To U.S. | From U.S. | To U.S. | From U.S. | To U.S. | From U.S. | To U.S. | From U.S. |
| 363, 364, 369 | . . Other Electrical Machinery, Equipment & Supplies | 8 | 126 | 12 | 215 | 49 | 57 | 144 | 277 | 2 | 64 | 53 | 145 | 3 | 10 | 251 | 448 | 98 | 362 | 2 | 2 | 99 | 260 |
| 363 | . . . Household Appliances | 4 | 33 | 5 | 87 | 16 | 23 | 24 | 100 | 2 | 32 | 14 | 37 | 2 | 7 | 65 | 144 | 18 | 108 | 1 | – | 48 | 77 |
| 364 | . . . Electrical Lighting & Wiring Equipment | 1 | 30 | 4 | 41 | 9 | 4 | 59 | 52 | – | 9 | 29 | 41 | – | – | 85 | 100 | 26 | 83 | – | 1 | 15 | 44 |
| 369 | . . . Miscellaneous Electrical Machinery, Equipment & Supplies | 3 | 63 | 3 | 86 | 24 | 29 | 61 | 124 | – | 23 | 10 | 67 | 1 | 3 | 101 | 203 | 53 | 170 | 1 | 1 | 36 | 139 |
| 365–367 | . Communication Equipment & Electronic Components | 12 | 270 | 14 | 421 | 58 | 105 | 324 | 701 | 3 | 65 | 157 | 431 | 5 | 30 | 442 | 1,114 | 245 | 922 | 6 | 3 | 128 | 548 |
| 365 | . . Radio & Television Receiving Equipment, Except Communication Types | 1 | 39 | 1 | 50 | 8 | 19 | 52 | 122 | – | 11 | 27 | 83 | – | 10 | 70 | 187 | 32 | 160 | – | – | 22 | 94 |
| 366–367 | . . Electronic Components & Accessories & Communication Equipment | 12 | 268 | 14 | 414 | 58 | 104 | 320 | 698 | 3 | 62 | 156 | 427 | 5 | 30 | 429 | 1,106 | 245 | 915 | 6 | 3 | 126 | 539 |
| 37, 348 | Transportation Equipment | 7 | 91 | 20 | 305 | 30 | 26 | 251 | 336 | 3 | 61 | 23 | 68 | 1 | 5 | 444 | 454 | 196 | 362 | 2 | 3 | 127 | 314 |
| 371, 373–376, 379 (except 3795) | . Motor Vehicles & Other Transportation | 7 | 84 | 19 | 290 | 29 | 26 | 228 | 321 | 3 | 61 | 23 | 64 | 1 | 5 | 432 | 426 | 183 | 329 | 1 | 3 | 124 | 298 |
| 371 | . . Motor Vehicles & Motor Vehicles Equipment | 5 | 42 | 12 | 178 | 11 | 15 | 158 | 220 | – | 40 | 13 | 41 | 1 | 2 | 297 | 307 | 110 | 219 | 1 | 3 | 69 | 171 |
| 376 | . . Guided Missiles & Space Vehicles & Parts | – | 21 | – | 35 | 6 | 6 | 26 | 38 | – | 4 | 1 | 5 | – | 1 | 34 | 48 | 16 | 47 | – | – | 5 | 40 |
| 373–375, 379 (except 3795) | . . Other Transportation Equipment | 1 | 22 | 9 | 88 | 5 | 4 | 95 | 95 | 2 | 25 | 9 | 25 | – | 2 | 132 | 131 | 66 | 114 | – | – | 50 | 122 |
| 373 | . . . Ship & Boat Building & Repairing | – | 6 | 2 | 28 | 1 | 2 | 13 | 43 | – | 4 | 6 | 10 | – | 1 | 29 | 37 | 17 | 30 | – | – | 18 | 61 |
| 374 | . . . Railroad Equipment | – | 14 | 3 | 42 | 4 | 2 | 71 | 52 | 2 | 21 | 2 | 11 | – | 1 | 100 | 85 | 40 | 74 | – | – | 22 | 58 |
| 375 | . . . Motorcycles, Bicycles & Parts | – | 4 | 1 | 7 | – | – | 14 | 12 | – | 2 | 1 | 4 | – | – | 11 | 20 | 9 | 19 | – | – | 2 | 23 |
| 379 (except 3795) | . . . Miscellaneous Transportation Equipment | 1 | 9 | 6 | 51 | 1 | – | 68 | 57 | – | 10 | 2 | 12 | – | – | 73 | 93 | 40 | 80 | – | – | 27 | 54 |
| 348, 3795 | . . Ordinance Except Missiles | 1 | 6 | 1 | 22 | 8 | 1 | 9 | 15 | 1 | 2 | 1 | 2 | – | – | 36 | 21 | 20 | 21 | – | – | 15 | 15 |
| 372 | . Aircraft & Parts | 2 | 26 | 7 | 78 | 5 | 7 | 111 | 112 | – | 15 | 8 | 22 | – | 2 | 162 | 161 | 63 | 120 | 2 | – | 31 | 94 |
| 38 (except 3825) | Professional & Scientific Instruments | 11 | 304 | 26 | 416 | 137 | 114 | 284 | 676 | 7 | 113 | 49 | 124 | 9 | 28 | 545 | 1,13[illegible] | 176 | 894 | 10 | 2 | 250 | 660 |

* *All other countries covered by the Derwent data base (see Table 1-1 in Section 1) except Japan, the data for Japan being incomplete.*

# APPENDIX B

## OBTAINING PREVIOUS OTAF PUBLICATIONS

Copies of the previous OTAF publications listed below are available from:

National Technical Information Service (NTIS)
5285 Port Royal Rd.
Springfield, Virginia 22161
(703) 557-4690

When ordering from NTIS, please give the publication title and its "COM" or "PB" number.

1. Initial Publication, May 1973
   COM 73-10767; Cost: Domestic - $6.50 Foreign - $13.00

   Describes OTAF program and gives sample reports on 24 wide ranging areas of technology in varying levels of detail.

2. Early Warning Report, December 1973
   COM 74-10150; Cost: Domestic - $11.00 Foreign - $22.00

   Spotlights those technological areas experiencing a high level of overall activity or of foreign activity. Reviews patent activity in a number of energy areas, including nuclear; solar; geothermal; and tide, wind and wave energy.

3. Third Report, June 1974
   COM 74-11383; Cost: Domestic - $9.00 Foreign - $18.00

   Presents an overview of the technological activity, across all technologies, of a group of selected foreign countries and a group of selected U.S. states. Extends energy area treatments to include oil shale and coal gasification technologies. Reviews additional high overall activity technological areas.

4. Fourth Report: A Review of Patent Ownership, January 1975
   COM 75-10050; Cost: Domestic - $7.25 Foreign - $14.50

   Identifies the 73 corporations and government agencies which received 500 or more patents during the five year period 1969-1973, and reviews and compares their patent activity across the spectrum of technology. Also reviews in terms of patent ownership, the patent activity during the same period, in nuclear energy technology and oil shale and coal gasification technology.

5. Fifth Report, August 1975
COM 75-11142, Cost: Domestic - $8.00 Foreign - $16.00

Reviews 60 technological areas, not previously reported on, experiencing a high level of overall activity or of foreign activity. Presents patent activity data in categories corresponding to 36 Product Fields of the Standard Industrial Classification System.

6. Sixth Report, June 1976
PB 254188, Cost: Domestic - $9.00 Foreign - $18.00

Reviews 15 technologies with unusually high activity by foreign resident inventors, and 22 high overall activity technologies; updates the 1973 reports on patent activity in solar and other natural energy sources, and adds reports on the use of waste material and wind for energy generation. Presents comparisions of patenting to R&D expenditures and R&D manpower allocations in six selected industries. The report concludes with a review of six most often cited patents in 1975, 5 U.S. and 1 foreign patent.

7. Seventh Report, March 1977*
PB 265792, Cost: Domestic - $9.25 Foreign - $18.50

Reviews historical patenting and trademark registration trends, and includes the most extensive collection of historical U.S. patent data ever presented in a single publication. Makes first use in the series of data relating to patents granted by foreign nations for a study of invention sources. Makes first use in the series of pending patent application data for forecasting. Presents brief reviews of 16 technologies experiencing high overall or foreign patent activity. Concludes with the series most comprehensive assessment of activity in a given technology, specifically in computer memories.

NTIS Microfilm of Previous Reports
Domestic - $3.00 per report; Foreign - $4.50 per report

*NOTE:

*The Seventh Report may also be obtained from the Superintendent of Documents; U.S. Government Printing Office; Washington, D. C. 20402. Their identification number is: 003-004-00542-4, price: Domestic $4.25

# APPENDIX C

## OBTAINING ADDITIONAL INFORMATION OR SPECIAL REPORTS

### Background

OTAF's computerized base of data relating to the patent file includes, at present:

- all subclasses of the U.S. Patent Classification System
- the relationship of all subclasses of the U.S. Patent Classification System to the Standard Industrial Classification System in 55 Product Fields and Product Field combinations
- for all U.S. patents, their recorded locations within the U.S. Patent Classification System
- for U.S. patents issued since 1963,
    - the ownership at time of issue in seven categories (U.S. government, foreign government, U.S. corporation, foreign corporation, U.S. individual, foreign individual, and unassigned)
    - the country or state of residence of the inventor
- for U.S. patents issued since 1967, the date the application for patent was filed in the U.S. Patent and Trademark Office.
- for U.S. patents issued since 1969, the specific (i.e. named) ownership of all patents which, at time of issue, were organizationally owned (e.g., by a corporation, foundation, government agency).
- for U.S. patents issued since 1975, the patent title, and the field of search and references cited in the patentability examination leading to the patent grant.

### Special Reports

Data can be retrieved on the basis of any one or any combination of the factors listed above, manipulated on most any given basis and presented in a number of formats, e.g., lists, tables, graphs, charts, etc. This flexibility is illustrated by the various types of reports presented in this and the seven preceeding OTAF publications.

OTAF has developed three standard special report programs which are designed to extract and present, for any given grouping of patents, a wide variety of data. Excerpts from samples of these reports -- the "country/company table report", the "patent activity profile report" and the "patent classification comparison profiles" -- are included in this Appendix.

## How to Obtain Special Reports

1. In making an initial determination of interest in a special OTAF report, you are urged to review the data items that are available and decide if any one or combination of them, or any relationship between two or more of them, might be useful to your needs. Special attention should be given to the standard format reports to determine if these multi-purpose, relatively low cost reports would meet your needs.

2. In most instances, interest, once determined, will be limited to particular technological areas or to particular patentees. In the case of technological areas, their definition is of key importance and must ultimately be in terms of classes and subclasses of the U.S. Patent Classification System (or one of the 55 SIC Product Fields or Field combinations). If you are unfamiliar with the U.S. Patent Classification System, develop as clear and precise an explanation of your area(s) of interest as possible.

3. At this point, you should contact OTAF, indicate the type of information you desire and, if you wish, what your needs are. (Perhaps alternatives can be suggested to better meet those needs). If you cannot provide class and subclass definition of your area of interest, OTAF will attempt to do that for you, using your description of the area.

4. Once there is a clear mutual understanding of the information you want, the format in which you want it and the area(s) to be included, an estimate of cost will be developed and provided to you along with a statement of the work to be done.

5. Once agreement on work to be done and cost is reached, and payment is received, the report will be prepared and provided.

## Costs

All special reports are prepared on a cost reimbursable basis. These costs may vary widely - from as low as $25.00 for a single country/company table report in groups of 10 or more, to several thousand dollars for complex and large scale treatments of many technological categories, requiring extensive professional time, or programming and/or computer time.

## Whom to Contact

Inquiries concerning OTAF publications/services are invited and should be directed to:

Office of Technology Assessment
and Forecast
U. S. Patent and Trademark Office
Washington, D. C. 20231
Phone: (703) 557-3050

## "Country/Company Table" Report

On the following five pages are excerpts from a standard format, OTAF special report. The total report -- on Natural Color TV -- is some 15 pages in length. The first page of the excerpt, titled "Explanation of Data", gives an overview of what is included in one of these reports.

## "Patent Activity Profile" Report

Following the country/company table report are excerpts from the second of OTAF's standard format special reports. The sample report profiles the 1969-1976 patent activity of the Bulova Watch Company across the classes and subclasses of the U. S. Patent Classification system. Two pages of the nine page report are included. This type of report can be prepared on the patents of any company or grouping of companies, or on the patents granted to the residents of any state or country or grouping of states or countries.

## "Patent Classification Comparison" Profiles

Following the patent activity profile report is an excerpt from the third of OTAF's standard format special reports. Like the patent activity profile report, this sample report also profiles 1969-1976 patent activity across the classes and subclasses of the U. S. Patent Classification system. In this report, however, the activity of up to eight organizations can be profiled simultaneously, facilitating comparisons between organizations.

## SIC Product Field Reports

Following the patent classification comparison profile is a listing of Standard Industrial Classification (SIC) Product Fields for which a concordance exists with subclasses of the U. S. Patent Classification System. Special patent reports, such as the "Country/Company Table Report", can be prepared for any of these Product Fields.

## SAMPLE - COUNTRY/COMPANY TABLE REPORT - NATURAL COLOR TV

## EXPLANATION OF DATA

### Description of Recent Activity

In each report, patent activity is profiled from 1963 - 1976E. The latter is an estimate for 1976 obtained by doubling patent output for the first six months of this year.

Each report begins with an "Activity Indices" table. Covering calendar years 1973-76E, the table presents for the area, information as to the:

- Average Percent Growth, number of patents issued in the period 1974-76E, divided by the total number of patents in the period 1967-76E.

- Average Percent Foreign , the number of patents issued to residents of foreign countries in the years 1974-76E, divided by total number of patents issued in these years

- Average Percent Corporate Owned, the number of 1974-76E patents assigned at time of issue to U.S. or foreign non-government organizations --mainly corporations -- divided by the total number of patents issued in this three year period

- Average Percent Government Owned, the number of 1974-76E patents assigned at time of issue to the U.S. or a foreign government divided by total number of patents issued in this three year period.

- Average percent U.S. Owned of Foreign, the number of 1974-1976E patents with a foreign resident inventor that are assigned to a U.S. organization, divided by the number of patents with a foreign resident inventor in these years.

- XR/OR Ratio, the number of 1974-76E patents with a cross reference designation, divided by the number of patents with an original (primary designation.

### Tables

In the 2nd through 5th pages of each active area report, tables are presented showing by number and percent the patent activity in the area from 1963 through 1976E -- first by date of patent grant (2nd and 3rd pages) and then by date of application filing for patents granted from 1967-June 30, 1976 (4th and 5th pages).

Each of these tables presents the data in several ways:

. Total
. U.S. Origin - inventor a U.S. resident
. Foreign Origin - inventor a foreign resident

The foreign origin data are further subdivided by the country of inventor residence. Data breakdown based on patent ownership is also given both for the U.S. origin patents and the foreign origin patents.

Distributing 1967-June 30, 1976 patents on an application date basis provides essentially complete data on those applications, which ultimately became patents, filed each year from 1965 through 1973. This is the case because there is a delay between the filing of a patent application and its subsequent issuance as a patent. The length of this delay (i.e., the "pendency" of an application) is determined by many factors, including Patent and Trademark Office workload (which varies between technologies), budget and man-power levels, patent printing schedules, etc.

In 1967, when maintenance of application date data in machine readable form began (and thus became subsequently available for inclusion in the OTAF data base) the average patent pendency was substantially in excess of two years. Consequently, patent applications filed in 1965 and 1966 were not issuing as patents until 1967 or later.

By June of 1976, as a result of an ambitious and successful Patent and Trademark Office program, the average pendency had been reduced to about 20 months. This current average pendency renders the patents by application date data shown for years subsequent to 1973 (i.e., 1974 - June 30, 1976) incomplete. The obvious reason for this is that a significant number of the applications filed in 1974 and most of those filed in 1975 and 1976 are still pending, have not, as yet, appeared as patents and, therefore, are not reflected in the OTAF data base.

It should note that only applications which ultimately matured into patents are reflected in the application date data. Those applications which were filed but never issued (roughly 30% of total filings) are not included.

OTAF feels that the application date data are of significant value, for the date an application is filed is a more accurate reflection of when the technology was developed. Additionally, fluctuation in data based on application date is much more likely to reflect changes in technological activity, since such fluctuation would, for the most part, be immune from, rather than the result of changes in Patent and Trademark Office application processing.

The remaining pages are directed to a distribution of patenting by patent assignees having received, from January 1969 through June 1975, a number of patents equal to or greater than a given "cut-off" number (indicated in page heading). This patenting is given, by year, both by patent grant date and by patent application date. The specific patent numbers are listed, by assignee, at the end of the report.

### Patents Included In Profiles

The user should be aware that patent activity profiles are generated by first identifying key Patent and Trademark Office classifications, i.e., those entirely or substantially pertinent to the technology of interest. All the patents in these classifications are included in the profile. This procedure results, in most cases, with the inclusion of the majority of patents relevant to the technology and few, if any non-relevant patents. However, any patent listing provided should not be considered to be inclusive of all relevant patents, nor exclusive of all non-relevant patents.

PATENT ACTIVITY (1963-1976E) BY DATE OF PATENT GRANT

| | NUMBER OF PATENTS | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PRE 63 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976E | TOTAL |
| TOTAL | | 49 | 42 | 44 | 92 | 88 | 55 | 96 | 165 | 228 | 168 | 227 | 151 | 121 | 182 | 1708 |
| U.S. ORIGIN | | 37 | 29 | 33 | 53 | 56 | 43 | 68 | 111 | 141 | 98 | 111 | 80 | 61 | 88 | 1009 |
| FOREIGN ORIGIN | | 12 | 13 | 11 | 39 | 32 | 12 | 28 | 54 | 87 | 70 | 116 | 71 | 60 | 94 | 699 |
| JAPAN | | 1 | 1 | 2 | 9 | 8 | 2 | 6 | 18 | 31 | 36 | 72 | 43 | 32 | 62 | 323 |
| GERMANY | | | 1 | 1 | 2 | 5 | 4 | 6 | 12 | 21 | 13 | 15 | 12 | 8 | 8 | 108 |
| UNITED KINGDOM | | 7 | 5 | 4 | 10 | 5 | 2 | 6 | 3 | 8 | 8 | 3 | 5 | 7 | 6 | 79 |
| NETHERLANDS | | 1 | 2 | 2 | 8 | 5 | 1 | 3 | 3 | 12 | 5 | 14 | 5 | 6 | 10 | 77 |
| FRANCE | | 3 | 3 | 2 | 7 | 6 | 3 | 4 | 5 | 4 | 2 | 5 | 3 | 1 | 4 | 52 |
| CANADA | | | | | | | | 1 | 5 | 7 | 3 | 4 | | 1 | 4 | 25 |
| SWITZERLAND | | | 1 | | 3 | 1 | | 2 | 3 | 3 | 3 | | 2 | 1 | | 19 |
| AUSTRIA | | | | | | | | | 1 | 1 | | 1 | 1 | 2 | | 6 |
| U.S.S.R. | | | | | | | | | 1 | | | | | 2 | | 3 |
| BELGIUM | | | | | | | | | 1 | | | 1 | | | | 2 |
| CZECHOSLOVAKIA | | | | | | 1 | | | | | | | | | | 1 |
| HUNGARY | | | | | | 1 | | | | | | | | | | 1 |
| ICELAND | | | | | | | | | 1 | | | | | | | 1 |
| ISRAEL | | | | | | | | | | | | 1 | | | | 1 |
| ARGENTINA | | | | | | | | | 1 | | | | | | | 1 |
| U.S. ORIGIN | | 37 | 29 | 33 | 53 | 56 | 43 | 68 | 111 | 141 | 98 | 111 | 80 | 61 | 88 | 1009 |
| U.S. CORP. OWNED | | 32 | 26 | 27 | 48 | 44 | 37 | 61 | 109 | 129 | 87 | 97 | 68 | 53 | 76 | 894 |
| U.S. GOVT. OWNED | | | | 1 | | 1 | | | | 1 | 3 | 1 | 1 | | 4 | 12 |
| U.S. INDIV. OWNED | | 5 | 3 | 5 | 5 | 10 | 6 | 7 | 2 | 10 | 8 | 13 | 11 | 8 | 4 | 97 |
| FOREIGN OWNED | | | | | | 1 | | | | 1 | | | | | 4 | 6 |
| FOREIGN ORIGIN | | 12 | 13 | 11 | 39 | 32 | 12 | 28 | 54 | 87 | 70 | 116 | 71 | 60 | 94 | 699 |
| U.S. OWNED | | 4 | 8 | 4 | 12 | 6 | 2 | 7 | 10 | 25 | 14 | 16 | 11 | 9 | 12 | 140 |
| FOREIGN OWNED | | 8 | 5 | 7 | 27 | 26 | 10 | 21 | 44 | 62 | 56 | 100 | 60 | 51 | 82 | 559 |
| FOREIGN CORP. | | 8 | 4 | 5 | 24 | 23 | 10 | 19 | 40 | 59 | 53 | 95 | 57 | 48 | 80 | 525 |
| FOREIGN GOVT. | | | | | | | | 1 | | | | | | | | 1 |
| FOREIGN INDIV. | | | 1 | 2 | 3 | 3 | | 1 | 4 | 3 | 3 | 5 | 3 | 3 | 2 | 33 |

NATURAL COLOR TV

PATENT ACTIVITY (PATENTS GRANTED 1/67-6/76) BY DATE OF PATENT APPLICATION

| | NUMBER OF PATENTED APPLICATIONS | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PRE 63 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | TOTAL |
| TOTAL | 5 | 15 | 53 | 79 | 119 | 123 | 120 | 137 | 173 | 174 | 158 | 115 | 102 | 16 | | 1389 |
| U.S. ORIGIN | 5 | 7 | 34 | 54 | 87 | 81 | 73 | 85 | 96 | 93 | 77 | 58 | 53 | 9 | | 812 |
| FOREIGN ORIGIN | | 8 | 19 | 25 | 32 | 42 | 47 | 52 | 77 | 81 | 81 | 57 | 49 | 7 | | 577 |
| JAPAN | | 2 | 5 | 7 | 8 | 10 | 16 | 22 | 46 | 48 | 45 | 34 | 30 | 6 | | 279 |
| GERMANY | | 1 | 2 | 7 | 10 | 9 | 12 | 10 | 12 | 10 | 15 | 8 | 4 | | | 100 |
| UNITED KINGDOM | | 1 | 5 | 3 | 5 | 2 | 4 | 5 | 6 | 4 | 5 | 5 | 5 | | | 50 |
| NETHERLANDS | | 1 | 2 | 3 | 1 | 6 | 5 | 7 | 5 | 12 | 8 | 4 | 5 | | | 59 |
| FRANCE | | 3 | 3 | 3 | 4 | 7 | | 2 | 2 | 4 | 3 | 2 | 2 | | | 35 |
| CANADA | | | | | | 6 | 5 | 3 | 2 | 2 | 2 | | 2 | 1 | | 23 |
| SWITZERLAND | | | | 2 | 1 | 2 | 3 | 1 | 2 | 1 | 2 | | 1 | | | 15 |
| AUSTRIA | | | | | 1 | | 1 | | 1 | | 1 | 2 | | | | 6 |
| U.S.S.R. | | | | | 1 | | | | | | | 2 | | | | 3 |
| BELGIUM | | | | | 1 | | | 1 | | | | | | | | 2 |
| CZECHOSLOVAKIA | | | 1 | | | | | | | | | | | | | 1 |
| HUNGARY | | | 1 | | | | | | | | | | | | | 1 |
| ICELAND | | | | | | | 1 | | | | | | | | | 1 |
| ISRAEL | | | | | | | | | 1 | | | | | | | 1 |
| ARGENTINA | | | | | | | | 1 | | | | | | | | 1 |
| U.S. ORIGIN | 5 | 7 | 34 | 54 | 87 | 81 | 73 | 85 | 96 | 93 | 77 | 58 | 53 | 9 | | 812 |
| U.S. CORP. OWNED | 4 | 3 | 26 | 47 | 77 | 79 | 70 | 79 | 85 | 78 | 70 | 47 | 48 | 9 | | 722 |
| U.S. GOVT. OWNED | | | | 1 | | | | 1 | 1 | 2 | 2 | | 2 | | | 9 |
| U.S. INDIV. OWNED | 1 | 4 | 8 | 6 | 9 | 2 | 3 | 4 | 10 | 13 | 5 | 11 | 1 | | | 77 |
| FOREIGN OWNED | | | | | 1 | | | 1 | | | | | 2 | | | 4 |
| FOREIGN ORIGIN | | 8 | 19 | 25 | 32 | 42 | 47 | 52 | 77 | 81 | 81 | 57 | 49 | 7 | | 577 |
| U.S. OWNED | | 1 | 3 | 5 | 7 | 10 | 15 | 10 | 13 | 15 | 12 | 8 | 7 | | | 106 |
| FOREIGN OWNED | | 7 | 16 | 20 | 25 | 32 | 32 | 42 | 64 | 66 | 69 | 49 | 42 | 7 | | 471 |
| FOREIGN CORP. | | 7 | 16 | 16 | 23 | 29 | 31 | 40 | 60 | 61 | 68 | 45 | 41 | 7 | | 444 |
| FOREIGN GOVT. | | | | 1 | | | | | | | | | | | | 1 |
| FOREIGN INDIV. | | | | 3 | 2 | 3 | 1 | 2 | 4 | 5 | 1 | 4 | 1 | | | 26 |

COMPANY PATENTING (1/69-6/76) -- COMPANIES WITH 5 OR MORE PATENTS

| | PRE 63 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RCA CORPORATION | | | | | | | | | | | | | | | | |
| PATENTS GRANTED | | | | | | | | 9 | 20 | 39 | 23 | 22 | 16 | 12 | 12 | 153 |
| PATENTED APPLICATIONS | | | | 2 | 9 | 11 | 25 | 23 | 19 | 18 | 16 | 10 | 16 | 3 | | 153 |
| SONY CORPORATION | | | | | | | | | | | | | | | | |
| PATENTS GRANTED | | | | | | | | 2 | 8 | 14 | 14 | 21 | 15 | 8 | 7 | 89 |
| PATENTED APPLICATIONS | | | | | 2 | 6 | 7 | 8 | 15 | 18 | 14 | 8 | 7 | 4 | | 89 |
| U.S. PHILIPS CORPORATION | | | | | | | | | | | | | | | | |
| PATENTS GRANTED | | | | | | | | 1 | 8 | 18 | 8 | 15 | 7 | 7 | 6 | 70 |
| PATENTED APPLICATIONS | | | | 2 | 2 | 6 | 11 | 7 | 8 | 13 | 9 | 6 | 6 | | | 70 |
| ZENITH RADIO CORPORATION | | | | | | | | | | | | | | | | |
| PATENTS GRANTED | | | | | | | | 7 | 7 | 12 | 9 | 7 | 2 | 2 | 4 | 50 |
| PATENTED APPLICATIONS | | | | 1 | 6 | 6 | 4 | 8 | 9 | 5 | 4 | 4 | 2 | 1 | | 50 |
| MOTOROLA INC. | | | | | | | | | | | | | | | | |
| PATENTS GRANTED | | | | | | | | 7 | 7 | 11 | 5 | 5 | 7 | 4 | 1 | 47 |
| PATENTED APPLICATIONS | | | | | 6 | 6 | 4 | 10 | 4 | 2 | 8 | 4 | 3 | | | 47 |
| MATSUSHITA ELECTRIC INDUSTRIAL COMPANY LIMITED | | | | | | | | | | | | | | | | |
| PATENTS GRANTED | | | | | | | | | 1 | 3 | 4 | 13 | 9 | 6 | 7 | 43 |
| PATENTED APPLICATIONS | | | | | 1 | | 1 | 4 | 7 | 6 | 9 | 8 | 7 | | | 43 |
| GENERAL ELECTRIC COMPANY | | | | | | | | | | | | | | | | |
| PATENTS GRANTED | | | | | | | | 6 | 3 | 9 | 4 | 11 | 5 | 2 | 2 | 42 |
| PATENTED APPLICATIONS | | | 2 | 2 | 4 | | 2 | 4 | 9 | 8 | 6 | 2 | 3 | | | 42 |
| FERNSEH GMBH DARMSTADT | | | | | | | | | | | | | | | | |
| PATENTS GRANTED | | | | | | | | | 6 | 13 | 10 | 7 | 2 | | | 38 |
| PATENTED APPLICATIONS | | | | | 2 | 4 | 7 | 9 | 8 | 4 | 4 | | | | | 38 |
| COLUMBIA BROADCASTING SYSTEM INC. < | | | | | | | | | | | | | | | | |
| PATENTS GRANTED | | | | | | | | 7 | 4 | 9 | 3 | 6 | 1 | | | 30 |
| PATENTED APPLICATIONS | 1 | | | | 8 | 3 | 3 | 6 | 2 | 3 | 3 | 1 | | | | 30 |
| HITACHI LIMITED | | | | | | | | | | | | | | | | |
| PATENTS GRANTED | | | | | | | | | | 3 | 4 | 5 | 7 | 4 | 6 | 29 |
| PATENTED APPLICATIONS | | | | | | | 1 | 2 | 5 | 5 | 5 | 5 | 6 | | | 29 |
| SYLVANIA ELECTRIC PRODUCTS INC. | | | | | | | | | | | | | | | | |
| PATENTS GRANTED | | | | | | | | 5 | 11 | 6 | 4 | 1 | | | | 27 |
| PATENTED APPLICATIONS | | | | | 4 | 9 | 8 | 2 | 4 | | | | | | | 27 |
| BELL TELEPHONE LABORATORIES INCORPORATED | | | | | | | | | | | | | | | | |
| PATENTS GRANTED | | | | | | | | | 5 | 1 | 8 | 4 | 3 | 1 | 2 | 24 |
| PATENTED APPLICATIONS | | | | | 1 | 1 | 3 | 2 | 6 | 3 | 4 | 2 | 2 | | | 24 |
| VICTOR COMPANY OF JAPAN, LIMITED | | | | | | | | | | | | | | | | |
| PATENTS GRANTED | | | | | | | | 1 | 2 | 2 | 5 | 6 | 3 | 1 | 2 | 22 |
| PATENTED APPLICATIONS | | | 1 | | 1 | 1 | | 4 | 6 | 1 | 4 | 2 | 2 | | | 22 |
| MAGNAVOX COMPANY, THE | | | | | | | | | | | | | | | | |
| PATENTS GRANTED | | | | | | | | | 1 | 1 | 6 | 2 | 5 | 1 | | 16 |
| PATENTED APPLICATIONS | | | | | | | 1 | 3 | 4 | 2 | 5 | 1 | | | | 16 |

ADMIRAL CORPORATION
3492413 3492414 3519734 3519735 3562412 3688021 3896330 3924067

AGFA-GEVAERT
3510571 3731994 3737574 3761609 3820992 3860950 3891975

AMPEX CORPORATION
3428745 3506777 3562413 3564123 3763317 3781464 3838310

BELL TELEPHONE LABORATORIES INCORPORATED
3507981 3530233 3531585 3534158 3534159 3604839 3634614 3647946 3652956 3653747 3668304 3681519
3699241 3700793 3716666 3720782 3730977 3732359 3784735 3789132 3803348 3860953 3953672 3953886

BELL + HOWELL COMPANY
3440341 3456069 3512094 3531584 3536827 3542947 3557302 3629491 3634616 3643294 3663743 3697673
3699243

BOSCH, ROBERT, FERNSEHANLAGEN GMBH
3736371 3752905 3764735 3787611 3793479 3808358 3820156

CENTRAL DYNAMICS, LTD.
3534157 3549793 3586759 3594498 3604844

COLUMBIA BROADCASTING SYSTEM INC. <
3459885 3461224 3475548 3475549 3479447 3479450 3483315 3506775 3522371 3535992 3536826 3571503
3585280 3585292 3591268 3598901 3603724 3604841 3609228 3614302 3655908 3678181 3679817 3730984
3732363 3735015 3735026 3755620 3780212 3829607

COMPAGNIE FRANCAISE DE TELEVISION
3471635 3485942 3518362 3526705 3553353 3581007

EASTMAN KODAK COMPANY
3644664 3710010 3748485 3751580 3751584 3783185 3794755 3795761 3879750 3908192

ELECTROHOME LIMITED
3463875 3502798 3562410 3705259 3755619 3895393 3961362

FERNSEH GMBH DARMSTADT
3496286 3510572 3510575 3536824 3539714 3541237 3553355 3553356 3576943 3580991 3586760 3586763
3588323 3590145 3610816 3610818 3614303 3614304 3626088 3637920 3637936 3646254 3651248 3652784
3652785 3660595 3666880 3674918 3681520 3708616 3715462 3729580 3735030 3739080 3755621 3772462
3789135 3798353

GENERAL CORPORATION THE
3436469 3484545 3507982 3527878 3770883 3772460 3772461

GENERAL ELECTRIC COMPANY
3422217 3429996 3435132 3437746 3450462 3471636 3504110 3538249 3540797 3585283 3586764 3591707
3592529 3597529 3601470 3609219 3622694 3627909 3646253 3673319 3674919 3676582 3711635 3715467
3715479 3728476 3729577 3730992 3736370 3742130 3750042 3751590 3763309 3806634 3806635 3806636
3814842 3852523 3873760 3928867 3943560 3950780

GTE SYLVANIA INCORPORATED
3619483 3619485 3619803 3621121 3700787 3706849 3764734 3787610 3830960 3882534 3922713 3949418
3962649 3962723

# SAMPLE - PATENT ACTIVITY PROFILE REPORT - BULOVA WATCH COMPANY

## EXPLANATION OF DATA

### DESCRIPTION OF PATENT PROFILES

THE REPORT PROFILES PATENTS, FALLING INTO A PARTICULAR CATEGORY (E.G., SPECIFIC OWNERSHIP, COUNTRY OR STATE OF INVENTOR RESIDENCE), BY THE CURRENT U.S. PATENT CLASSIFICATIONS INTO WHICH THOSE PATENTS HAVE BEEN PLACED.

EACH CLASS IS IDENTIFIED BY ITS TITLE. THEN, FOR EACH CLASS AND SUBCLASS WITHIN THAT CLASS, THE TOTAL, OR (ORIGINAL), XR (CROSS-REFERENCE) AND PCT (PERCENT) OR AND ALL (OR + XR) PATENTS IN THAT CLASSIFICATION ARE GIVEN. THESE ARE FOLLOWED BY THE PATENT NUMBERS IN THAT CLASSIFICATION. THE TYPE OF CLASSIFICATION (OR OR XR) ASSIGNED TO EACH PATENT IN THAT CLASSIFICATION IS GIVEN IN PARENTHESES FOLLOWING THE PATENT NUMBER.

### PATENTS INCLUDED IN PROFILE

THE PATENTS INCLUDED IN THE REPORT ARE THOSE WHICH, ACCORDING TO THE DATA OF RECORD IN THE OTAF COMPUTER DATA BASE, FALL WITHIN THE CATEGORY COVERED IN THE REPORT. THESE CATEGORY DATA ARE RECORDED AT THE TIME OF PATENT ISSUE AND ARE ESSENTIALLY ACCURATE. HOWEVER, ANY PATENT LISTING OR DATA PROVIDED IN THIS REPORT SHOULD NOT BE CONSIDERED TO BE INCLUSIVE OF ALL RELEVANT PATENTS, NOR EXCLUSIVE OF ALL NON-RELEVANT PATENTS.

OTAF SPECIAL REPORT
CLASSIFICATION PROFILE - (1969 - 1976) PATENTS ASSIGNED TO BULOVA WATCH COMPANY

CLASS 58 - HOROLOGY

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SUBCLASS 50 R | (CONTINUED) | | | | | | | | | | |
| 3777471 (XR) 3937002 (XR) | | | | | | | | | | | |
| SUBCLASS 58 | TOTAL | 3 | (OR) | 2 | (XR) | 1 | PCT OF TOTAL OR | 4.3 | PCT OF ALL (OR+XR) | 1.8 |
| 3421310 (OR) 3439493 (OR) 3935700 (XR) | | | | | | | | | | |
| SUBCLASS 85.5 | TOTAL | 5 | (OR) | 1 | (XR) | 4 | PCT OF TOTAL OR | 2.2 | PCT OF ALL (OR+XR) | 3.0 |
| 3421311 (OR) 3503203 (XR) 3739568 (XR) 3777471 (XR) 3935700 (XR) | | | | | | | | | | |
| SUBCLASS 88 R | TOTAL | 1 | (OR) | 0 | (XR) | 1 | PCT OF TOTAL OR | 0.0 | PCT OF ALL (OR+XR) | .6 |
| 3942316 (XR) | | | | | | | | | | |
| SUBCLASS 128 | TOTAL | 1 | (OR) | 0 | (XR) | 1 | PCT OF TOTAL OR | 0.0 | PCT OF ALL (OR+XR) | .6 |
| 3439493 (XR) | | | | | | | | | | |
| TOTAL CLASS 58 | TOTAL | 45 | (OR) | 17 | (XR) | 28 | PCT OF TOTAL OR | 37.0 | PCT OF ALL (OR+XR) | 26.9 |

CLASS 65 - GLASS MANUFACTURING

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| SUBCLASS 59 B | TOTAL | 1 | (OR) | 0 | (XR) | 1 | PCT OF TOTAL OR | 0.0 | PCT OF ALL (OR+XR) | .6 |
| 3805098 (XR) | | | | | | | | | | |
| TOTAL CLASS 65 | TOTAL | 1 | (OR) | 0 | (XR) | 1 | PCT OF TOTAL OR | 0.0 | PCT OF ALL (OR+XR) | .6 |

CLASS 73 - MEASURING AND TESTING

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| SUBCLASS 70.2 | TOTAL | 1 | (OR) | 0 | (XR) | 1 | PCT OF TOTAL OR | 0.0 | PCT OF ALL (OR+XR) | .6 |
| 3700304 (XR) | | | | | | | | | | |
| SUBCLASS 398 R | TOTAL | 1 | (OR) | 1 | (XR) | 0 | PCT OF TOTAL OR | 2.2 | PCT OF ALL (OR+XR) | .6 |
| 3628381 (OR) | | | | | | | | | | |
| SUBCLASS 406 | TOTAL | 1 | (OR) | 0 | (XR) | 1 | PCT OF TOTAL OR | 0.0 | PCT OF ALL (OR+XR) | .6 |
| 3628381 (XR) | | | | | | | | | | |
| TOTAL CLASS 73 | TOTAL | 3 | (OR) | 1 | (XR) | 2 | PCT OF TOTAL OR | 2.2 | PCT OF ALL (OR+XR) | 1.8 |

CLASS 81 - TOOLS

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| SUBCLASS 6 | TOTAL | 1 | (OR) | 1 | (XR) | 0 | PCT OF TOTAL OR | 2.2 | PCT OF ALL (OR+XR) | .6 |
| 3848484 (OR) | | | | | | | | | | |
| TOTAL CLASS 81 | TOTAL | 1 | (OR) | 1 | (XR) | 0 | PCT OF TOTAL OR | 2.2 | PCT OF ALL (OR+XR) | .6 |

SAMPLE - PATENT CLASSIFICATION COMPARISION PROFILES

1. WESTERN ELECTRIC COMPANY
2. BURROUGHS CORPORATION
3. CONTROL DATA CORPORATION
4. DIGITAL EQUIPMENT CORPORATION
5. GTE SYLVANIA INC.
6. GENERAL ELECTRIC COMPANY
7. HONEYWELL INC.
8. INTERNATIONAL BUSINESS MACHINES CORP.

# SAMPLE - PATENT CLASSIFICATION COMPARISON PROFILES
## EXPLANATION OF DATA

DESCRIPTION OF PATENT PROFILES

THE REPORT PROFILES PATENTS ASSIGNED TO UP TO EIGHT ORGANIZATIONS (CORPORATIONS, GOVERNMENTS, UNIVERSITY, ETC.) BY THE CURRENT U.S. PATENT CLASSIFICATIONS INTO WHICH THOSE PATENTS HAVE BEEN PLACED.

EACH CLASS IS IDENTIFIED BY ITS TITLE. THEN, FOR EACH CLASS AND SUBCLASS WITHIN THAT CLASS, THE NUMBER OF PATENTS (TOTAL) AND THE PERCENTAGE OF ALL PATENTS TO THAT ORGANIZATION (PCT) ARE GIVEN.

PATENTS INCLUDED IN PROFILE

THE PATENTS INCLUDED IN THE REPORT ARE THOSE WHICH, ACCORDING TO THE DATA OF RECORD IN THE OTAF COMPUTER DATA BASE, FALL WITHIN THE CATEGORY COVERED IN THE REPORT. THESE CATEGORY DATA ARE RECORDED AT THE TIME OF PATENT ISSUE AND ARE ESSENTIALLY ACCURATE. HOWEVER, ANY PATENT LISTING OR DATA PROVIDED IN THIS REPORT SHOULD NOT BE CONSIDERED TO BE INCLUSIVE OF ALL RELEVANT PATENTS, NOR EXCLUSIVE OF ALL NON-RELEVANT PATENTS.

OTAF SPECIAL REPORT
MULTI-CORPORATE PATENT ACTIVITY PROFILE - (1969 - 1976)

| | WESTERN ELEC | | BURROUGHS | | CONTROL DATA | | DIG EQUIP | | GTE SYLVANIA | | GENERAL ELEC | | HONEYWELL | | I B M | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TOTAL | PCT | TOTAL | PCT | TOTAL | PCT | TOTAL | PCT | TOTAL | PCT | TOTAL | PCT | TOTAL | PCT | TOTAL | PCT |
| CLASS 361 - ELECTRICITY. ELECTRICAL SYSTEMS AND DEVICES | | | | | | | | | | | | | | | | |
| SUBCLASS 404 | | | | | | | | | 1 | .1 | | | | | | |
| SUBCLASS 409 | | | | | | | | | | | | | | | 1 | .0 |
| SUBCLASS 411 | | | | | | | | | | | 1 | .0 | | | | |
| SUBCLASS 413 | | | | | 1 | 1.1 | 1 | 2.2 | 1 | .1 | | | | | | |
| SUBCLASS 414 | | | | | | | | | | | | | | | 1 | .0 |
| SUBCLASS 415 | 1 | .0 | | | | | | | 3 | .2 | 1 | .0 | 2 | .2 | | |
| SUBCLASS 416 | | | | | | | | | 1 | .1 | 1 | .0 | | | | |
| SUBCLASS 424 | | | | | | | | | 1 | .1 | | | | | | |
| SUBCLASS 428 | 1 | .0 | | | | | | | | | | | | | | |
| SUBCLASS 433 | 2 | .1 | | | | | | | | | 7 | .2 | 1 | .1 | 1 | .0 |
| SUBCLASS 434 | | | | | | | | | | | 1 | .0 | | | | |
| TOTAL CLASS 361 | 28* | 1.0 | 9* | 1.6 | 2* | 2.2 | 1* | 2.2 | 29* | 2.1 | 141* | 3.1 | 17* | 1.6 | 25* | .9 |
| CLASS 364 - ELECTRICAL COMPUTERS AND DATA PROCESSING SYSTEMS | | | | | | | | | | | | | | | | |
| SUBCLASS 200 | 27 | .9 | 69 | 12.5 | 3 | 3.3 | 15 | 33.3 | 26 | 1.8 | 7 | .2 | 104 | 10.0 | 160 | 5.8 |
| SUBCLASS 300 | 6 | .2 | 1 | .2 | 1 | 1.1 | | | | | | | 4 | .4 | 5 | .2 |
| SUBCLASS 900 | 18 | .6 | 6 | 1.1 | 1 | 1.1 | | | 7 | .5 | 11 | .2 | 7 | .7 | 52 | 1.9 |
| TOTAL CLASS 364 | 51* | 1.8 | 76* | 13.8 | 5* | 5.4 | 15* | 33.3 | 33* | 2.3 | 18* | .4 | 115* | 11.1 | 217* | 7.8 |
| CLASS 403 - JOINTS AND CONNECTIONS | | | | | | | | | | | | | | | | |
| SUBCLASS 11 | | | | | | | | | | | 2 | .0 | | | | |
| SUBCLASS 15 | | | | | | | | | | | 1 | .0 | | | | |
| SUBCLASS 28 | | | | | | | | | | | 1 | .0 | | | | |
| SUBCLASS 104 | | | | | | | | | | | | | | | | |

## SIC PRODUCT FIELDS

| PRODUCT FIELDS | SIC CATEGORY |
|---|---|
| Food and Kindred Products | 20 |
| Textile Mill Products | 22 |
| Chemicals and Allied Products | 28 |
| Chemicals, Except Drugs & Medicines | 281, 282, 284-289 |
| Basic Industrial Inorganic & Organic Chemistry | 281, 286 |
| Industrial Inorganic Chemistry | 281 |
| Industrial Organic Chemistry | 286 |
| Plastics Materials & Synthetic Resins | 282 |
| Agricultural Chemicals | 287 |
| All Other Chemicals | 284, 285, 289 |
| Soap, Detergents, and Cleaning Preparations, Perfumes, Cosmetics & Other Toilet Preparations | 284 |
| Paints Varnishes, Lacquers, Enamels, and Allied Products | 285 |
| Miscellaneous Chemical Products | 289 |
| Drugs and Medicines | 283 |
| Petroleum & Natural Gas Extraction & Petroleum Refining | 13, 29 |
| Rubber & Miscellaneous Plastics Products | 30 |
| Stone, Clay, Glass and Concrete Products | 32 |
| Primary Metals | 33, 3462, 3463 |
| Primary Ferrous Products | 331, 332, 3399, 3462 |
| Primary & Secondary Non-Ferrous Metals | 333-336, 339 (except 3399), 3463 |
| Fabricated Metal Products | 34 (except 3462, 3463, 348) |

| PRODUCT FIELD | SIC CATEGORY |
|---|---|
| Machinery, Except Electrical | 35 |
| Engines & Turbines | 351 |
| Farm & Garden Machinery & Equipment | 352 |
| Construction, Mining & Material Handling Machinery & Equipment | 353 |
| Metal Working Machinery & Equipment | 354 |
| Office Computing & Accounting Machines | 357 |
| Other Machinery, Except Electrical | 355, 356, 358, 359 |
| Special Industry Machinery, Except Metal Working Machinery | 355 |
| General Industrial Machinery & Equipment | 356 |
| Refrigeration & Service Industry Machinery | 358 |
| Miscellaneous Machinery, Except Electrical | 359 |
| Electrical and Electronic Machinery, Equipment and Supplies | 36, 3825 |
| Electrical Equipment, Except Communication Equipment | 361-364, 369, 3825 |
| Electrical Transmission & Distribution Equipment | 361, 3825 |
| Electrical Industrial Apparatus | 362 |
| Other Electrical Machinery, Equipment & Supplies | 363, 364, 369 |
| Household Appliances | 363 |
| Electrical Lighting & Wiring Equipment | 364 |
| Miscellaneous Electrical Machinery, Equipment & Supplies | 369 |

| PRODUCT FIELD | SIC CATEGORY |
|---|---|
| Communication Equipment & Electronic Components | 365-367 |
| Radio & Television Receiving Equipment, Except Communication Types | 365 |
| Electronic Components & Accessories & Communication Equipment | 366-367 |
| Transportation Equipment | 37, 348 |
| Motor Vehicles & Other Transportation | 371, 373-376, 379 (except 3795) |
| Motor Vehicles & Motor Vehicles Equipment | 371 |
| Guided Missiles & Space Vehicles & Parts | 376 |
| Other Transportation Equipment | 373-375, 379 (except 3795) |
| Ship & Boat Building & Repairing | 373 |
| Railroad Equipment | 374 |
| Motorcycles, Bicycles & Parts | 375 |
| Miscellaneous Transportation Equipment | 379 (except 3795) |
| Ordinance Except Missiles | 348, 3795 |
| Aircraft & Parts | 372 |
| Professional & Scientific Instruments | 38 (except 3825) |
| All Other | |

# APPENDIX D

## ACKNOWLEDGEMENTS

Patent and Trademark Office contributors to this publication are listed below. Special thanks are extended to Patent and Trademark Office professional and technical personnel whose continuing input to the Technology Assessment and Forecast program is indispensable.

### OFFICE OF TECHNOLOGY ASSESSMENT AND FORECAST

Staff:

William S. Lawson, Director
John F. Terapane, Ph.D., Senior Analyst
Henry D. Horn, Analyst
Gary R. Robinson, Data Control and Analysis Technician
Terry D'Amico, Secretary

Reports Coordinators for this Publication:

Nelson Moskowitz, Patent Examiner
Glennon H. Hollrah, Patent Examiner
Douglas A. Salser, Patent Classifier
Michael James, Intern

Graphics:

Chester A. Pawlaczyk, Draftsman
William J. Sale, Draftsman

Report Preparation Support:

Ruthela Calambro, Publication Aid
Ellen Peterson, Publication Aid
Jack Shifflett, Publication Aid
Debra Shouman, Publication Aid
Thomas True, Writer-Editor
Lydia Wytrez, Researcher
Ronald L. Knickerbocker, Bibliopegist

### CONSULTANTS

Section II
Pierre Coffin
Carol Johnson
William Maykrantz
Patricia Miller
Philip Morris, Ph.D.
Elizabeth Pan, Ph.D.
Walter Parker
Barbara Richtmyer
Gary Shoup
Mary Steddom
Marguerite Terbush
Dora Weinstein

Section III
Carol Johnson

Patent Examiners
Howard Birmiel
Archie Borchelt
Charles Hart
Cecilia Jaisle
Edward Meros
Jerry Myracle
Raphael Penland
Robert Reese
Yvonne Smith
Gerard Strecker
Oscar Vertiz
Thomas Wheelock
Maynard Wilbur
Donald Woodiel

☆ U.S. GOVERNMENT PRINTING OFFICE : 1978 O—252-745

PENN STATE UNIVERSITY LIBRARIES
A0000071883359